A Summary of Current Program and
Preliminary Report of Progress

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OILSEEDS AND PEANUT RESEARCH

of the

United States Department of Agriculture
and cooperating agencies

This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last two years. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
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Source materials used by the Advisory Committees are of two types. First there are organizational unit reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

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Three organizational unit reports are not reviewed in entirety by any one committee. All of the information in them is included in the subject matter reports.

Agricultural Research Service (ARS)

Agricultural Engineering
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SUBJECT MATTER PROGRESS REPORTS

The other type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

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A copy of any of the reports may be requested from James F. Lankford, Executive Secretary, Oilseed, Peanut and Sugar Crops Research Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C.

INTRODUCTION

This report deals with research directly related to the production, processing, distribution, and consumption of oilseeds and peanuts, and oilseed and peanut products. It does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only oilseed and peanut problems, but also to the problems of other commodities. Progress on cross-commodity work is found in the organization unit reports of the several divisions.

The report is presented under three main headings: Farm Research; Nutrition, Consumer, and Industrial Use Research; and Marketing and Economic Research. There is also a breakdown by problem areas as shown in the table of contents. For each area there is a statement of (1) the Problem, (2) the USDA Program, (3) a summary of Progress during the past year on USDA and cooperative work, and (4) a list of Publications resulting from USDA and cooperative work.

Oilseed and peanut research is supported by (1) Federal funds appropriated to the research agencies of the U. S. Department of Agriculture, (2) Federal and State funds appropriated to the State Agricultural Experiment Stations, and (3) private funds allotted, largely by oilseed and peanut industries, to research carried on in private laboratories or to support of State Station or USDA work.

Research by USDA

Farm Research in the Agricultural Research Service dealing with Oilseed and peanuts comprises investigations on breeding and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. This research is conducted by the Crops, Entomology, and Agricultural Engineering Divisions. The work involves 63.1 professional man-years of scientific effort.

Nutrition, Consumer and Industrial Use Research in the Agricultural Research Service pertains to improved methods and equipment for mill processing of oilseeds and peanuts; development of new and improved food, feed, industrial uses of oilseed and peanut products; and nutrient values of oilseeds and peanuts. It is carried out by the Eastern, Northern, Southern, and Western Utilization Research and Development Divisions; Consumer and Food Economics Research Division; and Human Nutrition Research Division. The work in these divisions involves 131.9 professional man-years of scientific effort.

Marketing and Economic Research is done in four services. Oilseed and peanut research in the Agricultural Marketing Service deals principally

with the physical and biological aspects of assembly, packaging, transporting, storing and distribution from the time the product leaves the farm until it reaches the ultimate consumer. It is carried out by the Market Quality, and Transportation and Facilities Research Divisions. The oilseed and peanut research in these divisions involves 9.2 professional man-years of scientific effort. Economic research conducted in the Economic Research Service deals with marketing costs, margins, and efficiency; market potentials; market structure, practices and competition; outlook and situation; and supply, demand, and price. Research in cooperative marketing is conducted by the Farmers Cooperative Service. The oilseed and peanut research in these services involves 9.3 professional man-years of scientific effort.

Interrelationships among Department, State, and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the station. Cooperative work is jointly planned, frequently with the representatives of the producers or industry affected participating. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators, which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects, oilseed and peanut research is in progress in about half of the 53 State Agricultural Experiment Stations. The type of work to which the largest amount of effort is devoted includes breeding and genetics, culture, diseases, variety evaluation, insect control, weed control, agricultural engineering, utilization, and economics. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

Industry's participation in oilseed and peanut research is carried out primarily by manufacturers of farm machinery and equipment, processors of intermediate products, such as unrefined vegetable oil, and by manufacturers of consumer products, such as shortening, margarine, and peanut butter.

Basic research done by the Department and States is utilized by industrial research laboratories in further development of improved products and equipment. Industry's cooperation in supporting oilseed and peanut research at Federal and State Stations has contributed greatly to its success.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Improved Method of Evaluating Disease-Resistant Castorbeans. Breeding castorbeans resistant to Botrytis mold will be greatly simplified and accelerated as a result of basic and applied research at Beltsville, Maryland. Botrytis mold causes losses in Texas, Arizona, Nebraska, and California and prevents production of castorbeans in humid areas of the Southeastern States. Basic research demonstrated that specific phenolic components and enzymes in resistant castorbeans react in injured tissues to produce oxidized compounds which inactivate the hydrolytic enzymes of the mold. When the natures of the complex chemical changes in host and parasite were known, it was possible to devise a simple color test which distinguishes resistant from susceptible plants. High correlations have been obtained between test results in the laboratory and resistance of plants in the field. The research has increased knowledge of the physiological mechanism involved in disease resistance in castorbeans and other plants and at the same time provided a useful tool for use in breeding disease-resistant castorbeans.

Phytophthora-Resistant Soybeans. Through cooperative research by 12 North Central State Agricultural Experiment Stations and Crops Research Division, Agricultural Research Service, 4 new soybean varieties resistant to Phytophthora rot were released in 1963. Phytophthora rot has been an increasing problem since its discovery in soybean fields in the mid-1950's. The new varieties--Hawkeye 63, Clark 63, Harosoy 63, and Lindarin 63-were all developed to replace the commercial varieties Hawkeye, Clark, Harosoy, and Lindarin.

Process Improved for Reducing the Flavor Unstable Component of Soybean Oil. Department research has shown how the yield of soybean oil with enhanced flavor stability can be increased in the hydrogenation-winterization process. Yields of oil containing only 1 percent of the flavor unstable component (linolenic acid) amount to 75 percent if selective hydrogenation conditions are used and if stearine (high-melting) fractions are removed by use of acetone. Based on other research of the Department that showed linolenic acid to be the principal cause of flavor instability of soybean oil, industry introduced a process for its removal by hydrogenation followed by winterization to remove high-melting saturated and *trans* acids. Oils so processed have significantly improved stability, but for economic reasons it is important to recover as much liquid oil as possible. With the improved process developed by the Department, this result is accomplished and, in addition, the stearine fraction is upgraded and can be more readily marketed. Although hydrogenation-winterization is not a complete answer to the flavor problem of liquid soybean oil, it is a practical procedure that contributes significantly to increased use of soybean oil for salad and cooking purposes.

New chemical product from linseed oil attracts industrial interest. New cyclic fatty alcohols resulting from the Department's utilization research on linseed oil are being evaluated for applications in the multimillion-pound market for long-chain fatty alcohols. Because of their unique cyclic structure, the new alcohols show unusual oil-like character and spreading properties not possessed by other long-chain alcohols of equal stability to oxidation. A major manufacturer is now testing cyclic linseed alcohols in its various products and is investigating their production for captive use and for sale to industry.

Potential of crambe as a new crop increased. Research on erucic acid, the principal fatty acid of crambe oil, and on processing crambe seed to produce palatable nutritious feed meal, has substantially increased the use potential for this new oilseed now under development in the Department's new crops research program. The practicability of conversion of erucic acid to dibasic brassylic acid in good yield and purity has been demonstrated and promising results have been obtained in study and evaluation of this dibasic acid in several industrial end-uses. Concurrent studies on processing crambe seed to oil and meal have revealed significant new information on biologically important components of the meal and have provided the basis for new techniques for obtaining feed meal with acceptable nutritional qualities.

Department research has shown that crambe, a plant related to rape and mustard, has excellent crop potential and gives satisfactorily high yields under dry-farming and irrigation conditions. It can be grown in place of crops now in over-abundant supply and in areas where there is no locally grown oilseed meal crop. Crambe oil would compete with imported rapeseed oil but not with presently grown domestic vegetable oils.

Industrial Possibilities of New Crops Examined. -- Physical science research in other Department agencies and economic evaluations by Economic Research Service are uncovering market possibilities for new crops not now grown on a commercial scale. Some of these may prove to be better alternatives for some farmers who presently are growing grains, cotton, or other surplus products. For example, physical science research has shown that seed of a new potential crop called Indian ironweed contains an oil that is important in the production of plastics. Recent economic investigations indicate that a large potential market (35 million pounds or more per year) exists for such oil at prices which could enable the profitable production of Indian ironweed in certain areas of the country. In fact, research toward early commercial adaptation of this crop is now being urged by potential industrial users. Recent investigations also indicate commercial possibilities for other new annual cash crops, such as vegetable gum crops, to reduce our dependence on imported materials, and annual crops for use as paper pulp raw materials.

I. FARM RESEARCH

SOYBEAN CULTURE, BREEDING AND GENETICS, DISEASES, AND VARIETY EVALUATION
Crops Research Div., ARS

Problem. Soybean varieties are adapted in maturity over relatively short distances from north to south. Since the maturity of a soybean variety is a function of the length of days in which it grows, its maturity is delayed by moving it north and hastened by moving it south and the maturity requirement alone necessitates a large number of soybean varieties. In addition, soil nutrients and moisture, diseases and climatic conditions at time of maturity greatly influence the adaptation of soybean varieties. For example, some of the best varieties in the central part of the United States produce excessively poor seed quality when grown at a similar latitude in the humid areas of the East Coast. Oil and protein are the two components of the soybean seed for which soybeans are produced commercially and these are negatively correlated. As a result of this correlation, maximum breeding progress in oil and protein requires a separate breeding program for each. More precise research information is needed on the most efficient breeding procedures to follow in improving oil and protein as well as yield and other agronomic characteristics; on why the maximum attainable yields of soybeans are relatively low in comparison to other crops; on the interrelationships of strains of nodulating bacteria and soybean varieties and on inoculation procedures that will permit the substitution of superior strains of nodulating bacteria for those already in the soil; on the disease organisms affecting soybeans, in particular newly discovered bacteria and fungi and diseases such as Phytophthora rot, downy mildew, and the soybean cyst nematode for which genetic variability in the disease organism is known to exist. There is also a need for the introduction, development, or identification of sources of resistance to some of the important diseases such as stem canker and brown stem rot. The increased number and prevalence of soybean diseases also has increased the need for precise information on the economic importance of the various diseases and their potential importance as a guide in assigning the available research effort to the most important diseases.

PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, physiologists, and biochemists engaged in both basic studies and the application of known principles to the solution of growers' problems. Genetics and breeding research is conducted at the Southwestern Irrigation Field Station at Brawley, California; Beltsville, Maryland; and in cooperation with the agricultural experiment stations at Gainesville, Florida; Urbana, Illinois; Lafayette,

Indiana; Ames, Iowa; Stoneville, Mississippi; Columbia, Missouri; and Raleigh, North Carolina. In addition, the evaluation of experimental selections from the genetics and breeding research is conducted in formal cooperation with the experiment stations at Auburn, Alabama; Fayetteville, Arkansas; Experiment, Georgia; Manhattan, Kansas; Lexington, Kentucky; Baton Rouge, Louisiana; E. Lansing, Michigan; St. Paul, Minnesota; Lincoln, Nebraska; Fargo, North Dakota; Columbus, Ohio; Stillwater, Oklahoma; Clemson, South Carolina; College Station, South Dakota; Knoxville, Tennessee; College Station, Texas; Blacksburg, Virginia; and Madison, Wisconsin; and in informal cooperation with experiment stations in other soybean producing states. Research on soybean diseases is conducted in cooperation with the agricultural experiment stations at Stoneville, Mississippi; Raleigh, North Carolina; Urbana, Illinois; Lafayette, Indiana; and Ames, Iowa. The variety evaluation research is conducted with the same type of cooperation as that for genetics and breeding. Research on culture and physiology is conducted in cooperation with the experiment stations at Urbana, Illinois; Lafayette, Indiana; Ames, Iowa; Stoneville, Mississippi; Columbia, Missouri; and at Beltsville, Maryland, and Brawley, California.

The Federal scientific effort devoted to research in this area totals 20.8 professional man-years. Of this number 8.6 is devoted to breeding and genetics; 6.0 to diseases; 1.7 to variety evaluation; 3.8 to culture and physiology; and 0.7 to program leadership.

PROGRESS

A. Genetics and Breeding

New varieties. One new variety, Hardee, was released in Florida, Georgia, and South Carolina in 1962. Hardee is resistant to several diseases and is superior in yield and other agronomic characteristics in the area where it is adapted. Hardee is the latest maturing variety released from the cooperative program and fills a special need in Southern production areas.

A new variety, Delmar, resistant to root-knot nematodes and diseases affecting seed quality was released in Delaware and Maryland in January 1963. Its resistance to root-knot makes it especially useful in rotation with other susceptible crops and its superior seed quality is a highly desirable attribute in Delaware and Maryland where seed quality is a major production problem.

Four new varieties developed by the backcross procedure were released in various states of the North Central area in January 1963. The varieties, Clark 63, Hawkeye 63, Harosoy 63, and Lindarin 63, were developed by backcrossing Phytophthora resistance to currently grown varieties of the same name. In addition, bacterial pustule resistance was added to Clark. In the absence of Phytophthora rot, the varieties

yield essentially the same as the original varieties but are much superior to the original varieties in areas where Phytophthora rot is a production problem. In Indiana, the yields of Harosoy, Hawkeye, Lindarin, and Clark on a Phytophthora problem field ranged from 17% of the new Phytophthora resistant varieties for Harosoy to 54% for Clark.

Association between back seedcoat and resistance to the cyst nematode. Attempts to develop a yellow-seeded soybean variety resistant to the soybean cyst nematode were again unsuccessful in 1962. The approximately twenty thousand plants that have been evaluated without identifying a true breeding yellow-seeded plant that is resistant to the soybean cyst nematode indicate the difficulties involved in developing yellow-seeded cyst nematode resistant varieties. Consequently, various techniques such as irradiation and other mutagenic agents, especially designed crosses, and the utilization of natural selection in very large populations are being explored in the attempt to break the association between black seed and the resistance to the cyst nematode.

Selections from the fourth backcross to Lee and other varieties were evaluated in infested fields in 1962 and the results indicated that near complete immunity of the resistant parent Peking was recovered in the backcross progenies. Seed of one selection from the third backcross to Lee was released for experimental purposes, but it is not expected to be of commercial value because of its black seed. The main purpose of the release was to make seed of an adapted selection available for large scale field studies on the effect of the nematode on the selection and of the effect of the selection on the nematode population. Since genetic variability in the nematode is known to exist it is important to ascertain as soon as possible whether the growing of a resistant variety will result in the development of a genetically different population of the nematode to which the variety might be susceptible. The selection released for experimental purposes is about the same as Lee in maturity and yields from 85 to 90% as much as Lee on noninfested soil. On infested soil the selection yields much more than Lee, the amount depending upon the intensity of the infestation.

Response to light. A small amount of light in the middle of the night will prevent most soybean varieties from flowering, and for most varieties, the type of light does not appear to be an important consideration. However, some varieties are not prevented from flowering by fluorescent light. In Mississippi this response to light was demonstrated to be inherited on a fairly simple basis and to be associated either genetically or chemically with pubescence color. Forty-four percent of the grey plants from a cross of a variety with grey pubescence with one with tawny pubescence were not prevented from flowering by fluorescent light. In contrast, ninety-four percent of the plants with tawny pubescence were prevented from flowering. The grey pubescent parent variety was not inhibited

by fluorescent light whereas the tawny one was.

Seed quality. Seed quality is a problem in all production areas where soybeans mature under warm humid conditions. Varieties vary greatly in seed quality but as yet no commercial variety is completely acceptable in areas where seed quality is a major problem. So-called summer types from Japan have proved to have exceptionally good seed quality in the United States. These are short season types in Japan that normally mature in the season of the year when the temperatures are high. These have been crossed with improved varieties of the United States and appear to offer promise in the development of acceptable seed quality for the humid areas.

Another approach to the problem has been to develop lines with a high percentage of hard or impermeable seed coats. The idea involved is that absorption of moisture by the seed coat of mature or nearly mature soybeans is one of the important factors in the deterioration of seed quality under humid conditions. The quality of hard seed persists under adverse conditions much longer than the quality of normal soybeans. However, there still is a question as to whether the limitation of hard seed in obtaining stands can be conveniently overcome even if hard seed does solve the quality problem.

Breeding for protein. In breeding for high protein various sources of high protein have been utilized. Early generation lines from some of the crosses averaging as high as 48-50% protein in the seeds have been evaluated on a preliminary basis. However, the agronomic performance of many of these lines is unacceptable and is unproven for others. In the most advanced program, lines of VI and VII maturity averaging about 46% protein in their seeds and essentially equal to current varieties in agronomic characteristics have been evaluated in Uniform Tests. Thus, high protein varieties could be made available immediately in some production areas but are much farther in the future in others.

B. Diseases

New diseases. In Mississippi, a new fungus was observed to infect roots and cause plugging of the water transportation system of the plant. However, the disease is considered to be of minor importance in commercial production. Of more importance, however, is a second fungus which when present with the fungus causing Phytophthora rot appears to aggravate the symptoms of Phytophthora rot and to cause some disease development on resistant varieties.

Brown stem rot was found for the first time in North Carolina and Virginia in the fall of 1962. This greatly extends the area affected by this particular disease since it has in the past been considered a disease of the North Central area.

Viruses. In Indiana results of field tests demonstrated that little or no infection by the tobacco ringspot virus, the virus that causes bud blight, could be attributed to soil transmission. All evidence to date indicates the transmission of the virus is by an aerial vector but a vector that will transmit the virus on any significant scale has not yet been identified. Cross pollination of plants infected with tobacco ringspot virus is unusually high and attempts are being made to utilize this phenomenon in the breeding program. Results in 1962 indicated that the high percentage of outcrossing is due to pollen sterility of the infected plants.

In North Carolina serological evaluations and host range comparisons indicated that viruses isolated from two locations in North Carolina were strains of the soybean mosaic virus. In field studies with the bean pod mottle virus and the two strains of soybean mosaic the effects of inoculation with the pod mottle virus and either of the two strains was much more severe than inoculations with either of the viruses alone or with the two strains of soybean mosaic. Yields of the plants inoculated with bean pod mottle virus and either of the two strains were much less than for other inoculations and mottling of the seed was much more severe.

Observations on disease organisms. In Indiana, the effects of various nutrient and environmental factors on the sporulation of the fungus causing frogeye leaf spot, Cercospora sojina, were investigated. One simple nutrient medium was found to induce excellent sporulation of the fungus at 24° C. This finding will make it possible to use spores of specific strains of the fungus in inoculating plants in the breeding program and permit the evaluation of plants for resistance to the disease in the greenhouse.

In North Carolina a population of the soybean cyst nematode from Tennessee was demonstrated to be physiologically different from the North Carolina population of the nematode. Also in North Carolina the apparent decline and the number of nematodes in an infested field as the soybean plants approach maturity was demonstrated to be a function of the rate of larval emergence from the cysts. Assays of the number of nematodes in the soil are based on the number of larvae that emerge from the cysts and the results indicated that the rate of emergence from cysts taken from the soil as the plants approached maturity was very low. However, if the cysts were left in the soil until the following spring the rate of emergence was again very high. In small plot tests resistant lines from the breeding program were found to reduce the number of nematodes per pint of soil from about 2100 to about 6 during one growing season. An important question is whether the nematodes that survived in the plots planted to the resistant lines are of the same genetic population as those that failed to survive or whether the few that survived represent a selected population that might eventually build up on the resistant lines.

C. Variety Evaluation

In breeding soybeans for high protein content in the seeds the amino acid balance of the protein also must be considered. Preliminary work has indicated that the amino acid balance of high protein genotypes is essentially the same as that for low protein types. However, the important consideration is the effect that changing protein level has on the limiting amino acids in soybean protein. Methionine is one of the most limiting amino acids in soybean protein as it is utilized commercially and this amino acid has been investigated in greater detail than others. Results from a large sample of high protein selections from the breeding program in 1962 provide additional evidence that methionine content of the protein is not being reduced in breeding for high total protein. Actually the data suggest a slight positive association between percentage of methionine in the protein and percentage of protein in the seed. If this relationship is real then methionine content of soybean protein can be expected to increase slightly as total protein is increased by breeding.

Approximately 16,000 samples of seed from all aspects of the research program were analyzed for oil and protein content.

D. Culture and Physiology

Response of soybeans to nutrients. In Iowa, toxicity symptoms previously attributed to high levels of phosphorus in the growing medium were found to be associated with very high numbers of a species of bacteria on the roots. Varieties resistant to the symptoms had few of the bacteria on the roots. Phosphorus toxicity symptoms were reduced as zinc in the nutrient solution was reduced and the number of bacteria on the roots was reduced accordingly. Zinc is known to be a bacteria inhibitor and the increased symptoms associated with reduced zinc are believed to be a function of reduced inhibition of the bacteria by the zinc.

The sensitivity of plants of some soybean varieties to high levels of phosphorus has been associated with a high rate of uptake and accumulation of phosphorus in above-ground parts. However, past research has failed to conclusively demonstrate whether tolerance of some varieties is due to something in the roots that prevents the uptake of the phosphorus or something in the tops that permits the phosphorus to be utilized rather than stored. Recent research in Illinois indicates that tolerance to high levels of phosphorus is conditioned by the root system.

Grafts involving sensitive and tolerant plants were made when the seedlings were very young so that tops of both tolerant and sensitive plants were grown on the roots of both tolerant and sensitive varieties. The response to phosphorus of the various combinations was

conditioned by the nature of the root system. If the roots were of a tolerant variety both tolerant and sensitive tops grafted to them appeared tolerant. Conversely, if the roots were of a sensitive variety both tolerant and sensitive tops grafted to them appeared sensitive. Thus, a mechanism controlling the uptake of phosphorus appears to control the response of soybeans to high levels of phosphorus.

In an attempt to develop an explanation of internal mechanisms of the plant that might account for the phosphorus tolerance and sensitivity, cotyledons of germinating seed of tolerant and intolerant types were studied under highly controlled conditions. The results indicated that respiration in cotyledons of sensitive plants was higher than in cotyledons of tolerant plants and suggested that some reaction involved in the utilization of phosphorus in the tolerant plants was not operating the same way in the sensitive plants. The mitochondria, bodies in plant cells known to be associated with energy relationships, were more efficient in the tolerant plants and could account for the capacity of tolerant varieties to incorporate organic phosphorus into usable organic form more rapidly than sensitive varieties.

The effect of temperature on the utilization of calcium by soybeans was also investigated in controlled experiments in Illinois. The effect of a given level of calcium on yield decreased at temperatures above about 72° F but the vegetative production of the plants was not similarly affected. The results suggest that a simple interaction between calcium and soil temperature could account at least in part for the erratic yields of soybeans under conditions where observable effects on the growth of the plants were not evident.

Nodulation. In Maryland and Iowa the strains of soybean nodulating bacteria in soils to be used for experimental purposes were identified serologically and strains that could be distinguished serologically from those already in the soil were used in inoculation experiments. Peat inoculum similar to the commercial product was prepared for experimental strains and applied in various manners and at various rates. The results were consistent with past experience and indicated that inoculum applied at the normal commercial rate resulted in virtually no nodules on the plants. Increasing inoculum rate of the strains increased the rate of success of some strains but not for others. Results seemed to indicate that some strains survived in the soil and that the rate of nodulation by these strains was a function of the amount of inoculum applied. Other strains apparently failed to survive in the soil long enough to produce nodules on the plants even when they were applied at up to 1200 times the normal rate of inoculation. Whether failure of survival is associated with chemicals used in the production of other crops in the rotation is unknown. However, the results clearly indicate that successful inoculation of soybeans is complex and that commercial inoculation in the usual recommended fashion is almost completely ineffective if the soil already contains nodulating bacteria.

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OILSEED CULTURE, BREEDING, DISEASES, AND VARIETY EVALUATION
Crops Research Division, ARS

Problem. There is urgent need for improved safflower varieties resistant to diseases, with reduced hull percentage, higher oil percentage and higher seed yield. Root-rot and rust continue to be important diseases in irrigated areas. Fusarium and Verticillium wilts have increased in importance during the past year. Cultural practices leading to establishment of full stands of plants are of first importance in the non-irrigated areas of Nebraska, Montana, and North Dakota.

For peanuts, more precise information is needed on: (1) the nature and control of important diseases; (2) the physiology of the plant including its unique reproductive system, mineral nutrition, and environmental factors affecting growth, and flowering and fruiting; (3) breeding behavior of the crop, including identification of and method of inheritance of characters of economic importance; and (4) identifying and measuring characteristics of peanuts associated with quality for specific end uses. Improved varieties with higher yield potential, resistance to diseases and insects, increased market acceptability, and enhanced nutritional properties are urgently needed to reduce the cost per unit of production of higher quality peanuts, thereby encouraging increased consumption of peanuts and peanut products.

A race of rust, race 300, new to North America has been found in Canada attacking varieties of flax hitherto immune to all North American races. Pasmo is estimated to have caused an average yield loss of 30% in South Dakota in 1962, with lesser losses in Minnesota and North Dakota. Improved varieties with higher yield of seed, oil content of the seed, and resistance to disease are needed urgently. More information is needed on the physiology of the flax plant, on the chemistry of oil quality, and the nature of the hypersensitive type of resistance to disease.

Inbred lines of castorbeans that combine well to provide F_1 hybrids with increased seed yield, improved oil content, resistance to diseases and lodging are required for commercial production. Further information on cultural practices including soil fertility and irrigation is needed.

The most urgent need in profitable sesame production is the breeding of improved varieties with high seed yield and quality, resistant to diseases, and suitable for mechanical harvesting. Varieties that have closed capsules at maturity or varieties with strong placenta attachment to retain the seed in opened capsules are needed.

The major problems in successful sunflower production are the control of diseases, chiefly rust, and the control of insect pests, chiefly the head moth. Rust control seems possible by plant breeding. However, no varieties or breeding lines have been found that are resistant to the head moth. Preliminary trials indicate considerable progress can be made in breeding hybrid sunflowers for commercial production.

Tung is a very promising crop for a geographic area just north of the Gulf of Mexico extending from south Georgia to east Texas except it has a low dormancy chilling requirement, hence begins to grow with the first warm weather and the flower buds get caught by late spring frosts. Methods are needed, either chemically to keep trees dormant, nutritionally or culturally to make trees more cold hardy or through breeding to find or develop a more cold hardy or later blooming clone. Mycosphorella leaf-spot, in some years, defoliates trees early, thus reducing oil content. Control for this disease, either chemical or through breeding, is urgently needed. More information on spacing, nutrition, cultural practices and variety testing is needed to enable more consistent and higher production at less cost.

PROGRAM

The Department has a continuing long-term program involving geneticists, plant pathologists, biochemists, physiologists, horticulturists, and agronomists engaged in both basic and applied studies of known principles to the solution of growers' problems. Safflower breeding, disease and cultural research is being carried on in cooperation with the California, Utah, Arizona, and Nebraska Agricultural Experiment Stations. Peanut breeding and variety evaluation research at Tifton, Georgia, and peanut disease investigations at Experiment, Plains, and Tifton, Georgia are cooperative with the Georgia Experiment Stations. Disease, culture, and variety evaluation research at Auburn and Headland, Alabama is cooperative with the Alabama Experiment Station. Peanut disease and variety evaluation research at Holland, Virginia is cooperative with the Virginia Experiment Station. Peanut variety evaluation and seed physiology research is carried on at Beltsville, Maryland. Flax research is conducted cooperatively with the Minnesota, North Dakota, and South Dakota Agricultural Experiment Stations, and at the Southwest Irrigation Field Station, Brawley, California. Castorbean breeding and genetics, disease control, and cultural trials are conducted in cooperation with the California, Texas, and Mississippi Agricultural Experiment Stations. Sesame research is conducted in cooperation with the Texas, Mississippi, and South Carolina Agricultural Experiment Stations. A limited program of sunflower research is conducted in cooperation with the Texas Agricultural Experiment Station. The Department has a continuing long-term tung program carried on at one central field location at

Bogalusa, Louisiana, with a field laboratory at Cairo, Georgia. The work is cooperative with the experiment stations of Mississippi and Louisiana. Much of the field work and experimental plantings are at the Mississippi Experimental Tung Farm, Poplarville, Mississippi.

The Federal scientific effort devoted to research in this area totals 31.3 professional man-years. Of this number, 9.2 is devoted to genetics and breeding; 8.2 to diseases; 4.2 to variety evaluation; 9.9 to culture; and 1.1 to program leadership. Pathologic research (safflower, castorbean, sesame, and mint) is carried on at Beltsville, Maryland. The composition and agronomic characteristics of peanut selections and the physiology of cell particulates are being studied under P.L. 480 projects.

PROGRESS

A. Breeding and Genetics

1. Safflower. A number of breeding lines of safflower have been developed that show considerable progress in one or more desirable characters. One line, designated U-15, has produced high seed yield with high oil percentage. It appears adapted to both irrigated and nonirrigated areas, but because it is not resistant to either rust or root-rot it cannot be grown in irrigated areas where diseases are likely to be serious. Another promising breeding line that has performed well in Arizona the past two years is A-0104. It has exceeded Gila, the current commercial variety, in both seed yield and oil content and appears to have a slight advantage over Gila in resistance to root-rot. At least two introductions have superior resistance to Phytophthora root-rot and should be useful in breeding resistant varieties. Breeding lines with striped hull selected from Gila have a higher oil and lower hull percentage than Gila. Both higher oil and higher protein in the meal result from less hull.

2. Peanut. A genetic marker expediting peanut breeding and genetic studies. Krinkle leaf, a monogenic dominant trait of Spanish origin has been a valuable tool in continuing studies at Tifton on the extent of natural crossing in peanuts, insects responsible for natural crossing, the implications of natural crossing in breeding methodology and in variety maintenance and stability, and the useful application of directed natural crossing in breeding and genetic investigations. In conjunction with directed natural crossing the Krinkle-leaf genetic marker has been used to expedite studies of genetic linkage and seedcoat color inheritance in peanuts. Krinkle leaf of seedlings is easily and unmistakably detectable two to three weeks after seed are planted. Without the use of such a marker results of inheritance and other genetic studies often are not known until the plants are grown to full maturity.

Accomplishments from use of Krinkle-leaf genetic marker and directed natural crossing include development of evidence that confirms a previously reported genetic ratio in inheritance of seedcoat color with critical proof that a flesh factor is prerequisite for red testa expression; the identification of two new white testa genotypes in peanuts; evidence that has been interpreted to show that 14 true-breeding peanut genotypes with white testa could result from the complex interaction of the known five factor pairs which control expression of red, flesh and white testa phenotypes; and evidence showing that no linkage exists between Krinkle and the 5 loci controlling seedcoat color inheritance.

Bees appear to be responsible for natural crossing in peanuts. Considerable variation has been found in tendency for natural crossing among types and varieties of cultivated peanuts and wild species of Arachis. Levels of natural crossing observed for many types and varieties are sufficiently high to have profound implications with regard to evolutionary development of peanuts and genetic variability therein. Although critical proof is lacking, strong circumstantial evidence indicates that bees are the principal agents effecting natural cross-pollination in peanuts. Eighteen species of solitary or social bees associated with peanut flowering at Tifton have been identified.

3. Flax. New race of flax rust. The discovery in Canada of a new race of flax rust attacking the LL gene found in a number of flax varieties points out the importance of breeding new varieties with resistance from new genes. A number of leading commercial varieties are susceptible to the new race. Backcross Bison lines are available that possess one, two, or three genes for resistance. Some of these should be resistant to the new race and can be increased rapidly for commercial release. Genetic studies have shown that resistance genes within the M and N series are tightly linked. New combinations can be obtained, however, and because of the infrequent cross over these new combinations can be used in a practical breeding program.

Irradiation breeding. Mutations in flax induced by irradiation have been observed. The relatively high rate of mutation, about 1 per 43,000 seedlings, indicates substantial genetic changes result from irradiation. Not all loci mutate readily, however, as shown by the failure to obtain a single rust-resistant genotype when susceptible Bison failed to produce a single resistant plant from among a progeny of 250,000 plants from irradiated seed.

Linkage studies. The first studies to determine possible linkages between loci for rust conditioning genes and plant characters has shown one gene for petal color, one for seed color, one for foliage color, and 3 rust genes may be present on the same chromosome. If it can be demonstrated there is a close association between readily observed marker genes and rust genes, the job of breeding for rust

resistance will be made easier.

Season, location, and date-of-sowing was shown to influence fatty acid composition of the seed. However, the relative rank of the varieties, particularly with respect to percentage of linolenic acid, remained fairly constant.

4. Castorbean. The variety Lynn was released to seed producers in Texas in 1962. Yields of seed fields ranged from 2300 to 2800 pounds per acre in the Plainview, Texas area.

Hybrid castorbean. Castorbean improvement at all stations now involves dwarf-internode varieties almost exclusively. Four years of yield comparisons in California have shown an average yield advantage of 12% for a dwarf-internode F_1 hybrid over a commercial normal-internode F_1 hybrid variety.

Heterosis for seed yield was considerably less at Lubbock, Texas than at Davis, California. The highest yielding hybrid exceeded the highest yielding inbred variety by 9 and 19% at Lubbock and Davis, respectively. In performance tests of 98 entries at Lubbock, none of the hybrids was significantly higher in seed yield than the better inbreds, while in tests of 89 entries at Davis, 30 F_1 hybrids were significantly higher. The yields of the better hybrids were comparable at the two locations while the better inbreds, Hale, Lynn, C7/192 and Baker 148 produced higher yields at Lubbock than at Davis. This points up the need for more genetic diversity to obtain adapted inbreds with different genotypes that maximize heterosis.

The relative performance of 28 F_1 hybrids for oil content in 1961 and 1962 at Davis was similar although oil content was higher in 1962. In 1961 the relative performance of these hybrids was also similar at Davis and Lubbock although oil content was higher at Lubbock.

This suggests that selection of hybrids for oil content at one location should be adequate. Regression coefficients of F_3 progenies on F_2 progenitors, although highly significant, were not of sufficient magnitude at Davis to warrant selection for oil content on an individual plant basis in the F_2.

Pistillate castorbean lines reduce roguing. Progress is continuing in the development of pistillate lines that will greatly reduce or possibly eliminate the roguing of monoecious plants in the production of F_1 hybrid seed. S-pistillate lines selected for several years under long growing seasons in southern Texas produced progenies in which 83 to 94% of the plants were pistillate at Lubbock, Texas. One line, TSP-10, has produced an average of 94% of pistillate plants for the past four years on the High Plains. In California, a perennial nursery was established at Brawley containing N-pistillate plants that are pistillate at Davis and interspersed monoecious at Brawley.

In 1962, progenies resulting from selfing these interspersed monoecious plants were again interspersed monoecious at Brawley and pistillate at Davis, thus demonstrating a method of producing seed of female lines for F_1 hybrid seed production without roguing. The genotypes of such plants consist of environmentally sensitive genes for interspersed staminate flowers and the environmentally insensitive N-pistillate gene f for pistillate flowers along the entire raceme axis. A similar genotype has been demonstrated for the last six years with N-pistillate Cimarron at Stillwater, Oklahoma.

Resistance to capsule-drop. Breeding for resistance to capsule-drop is of primary importance at Stoneville, Mississippi. Selections possessing resistance to capsule-drop which involve MW-1 and/or Baker 296 as sources of resistance have been advanced to the F_3, F_4, and F_5 generations. In addition to resistance to capsule-drop there is considerable variation for seed size, raceme length, sex and vigor. Preliminary yield tests indicate some lines are highly productive, having produced yields of 2700 to 3900 pounds of seed per acre. Performance at Lubbock, Texas showed that capsule indehiscence and resistance to Alternaria leaf-spot are also present in the material even though it has not been possible to apply selection pressure for these traits at Stoneville.

Resistance to Alternaria leaf-spot. Studies to determine the relationship between node of first raceme and resistance to Alternaria leaf-spot were conducted for the second year at Stillwater, Oklahoma. There was a highly significant correlation ($r = 0.576$) between high node number and resistance. Despite this it is believed selections with both earliness and resistance were made successfully. At Lubbock, Texas, breeding lines were evaluated for Alternaria leaf-spot. Certain progenies from the T 53222 cross have good resistance to Alternaria leaf-spot. Efforts to select lines resistant to capsule-mold and Alternaria leaf-spot have not been successful from crosses of Alternaria leaf-spot resistant lines and Baker 296 which has resistance to capsule-mold. Selection is under way utilizing the vanillin-iron-salts test to detect resistance to capsule-mold. Using this test as an indicator, about 25% of the F_3 plant selections from the crosses of Baker 296 X Hale and Baker 296 X C7/192 were resistant at Stillwater and Davis, respectively.

5. Sesame. Breeder seed of SI 47 was furnished the California Agricultural Experiment Station. This line was named Calinda and released to seed growers for production in California.

Breeding for seed retention. Breeding for strong placenta attachment has assumed major importance at Stoneville, Mississippi, where crosses have been made to combine strong attachment with long papershell capsules in both dehiscent and indehiscent lines. Two selections from one cross made the highest yields in 40-inch rows at Stoneville. These lines were late in maturity, had strong root systems, had ability to

produce seed late in the season, and were drought tolerant. At College Station, Texas, progress has been made in transferring strong placenta attachment to larger-seeded bacterial leaf-spot resistant dehiscent types. Progenies from parents with high and low seed retention averaged 94.4 and 78.8%, respectively. Progress in an attempt to combine strong placenta attachment with rough seed coat, a seed type easily decorticated by abrasion, has been disappointing.

A further increase in capsule length and diameter was observed at College Station, Texas when capsules over two inches long and larger in diameter than any bicarpellate capsules previously observed were produced. This may be an important step in breeding for larger capsules with greater ease in threshing and less mechanical damage to the seed.

In a genetic study of resistance to race 2 of Pseudomonas sesami, it was observed that resistance is recessive to susceptibility, but that more than a single gene, perhaps two to five, condition resistance. It has been more difficult to transfer resistance to race 2 of P. sesami to indehiscent than to dehiscent lines. A few indehiscent lines are partially resistant.

6. Sunflower. Increased self-incompatability useful in making F_1 hybrids. Commercial fields of hybrid sunflowers frequently contain less than 50% hybrids, the remainder being inbred plants from self pollination. Efficiency in affecting frequency of cross pollination in the production of hybrid seed was accomplished by a single cycle of recurrent selection for increased self-incompatability. The self-incompatible strain produced only 3.8 selfed seed per head under bags while the highly self-fertile strain produced an average of 179.8 seeds.

There are different races of sunflower rust in North America, demonstrated by the fact certain varieties and selections, resistant when grown at College Station, Texas, were susceptible at Morden, Manitoba. Other lines were resistant at both locations.

In trials at a number of locations in the United States the F_1 hybrid T 56002 was highest in yield. Some introduced varieties were higher in oil than domestic hybrids at all locations. Iodine number of the oil and calculated linoleic acid content of the oil was highest in Northern States, indicating the greater importance of environment compared with genotype.

7. Tung. The Department continued its long-term program to develop tung varieties having a late-blossoming characteristic to avoid the crop reducing hazard of early spring frosts. One approach has been the interspecific hybridization of the characteristically late-blooming Mu tree (Aleurites montana) with the more hardy but earlier blooming and commercially grown Tungtree (A. fordii). Another approach has been the selection and breeding of late-blooming kinds within the commercial

tung (A. fordii) itself.

Breeding for late-blossoming. Selected seedling progenies from F_2 seed of crosses between a late-blossoming selection G-46 and the Lampton and LaCrosse varieties were planted in 1961. In addition, more than 700 seedlings from open-pollinated seed of selections having the late-blossoming characteristic of the parent trees are being evaluated in the nursery. These seedling trees are being evaluated for late-blooming and other desirable horticultural characteristics. Test plantings have also been made of seedlings from crosses between a very late-blossoming selection, F-732, and other promising late-blooming, leaf-spot resistant selections. Clonally propagated trees of three outstanding late-blossoming selections, F-733, F-728, and F-729, have also been planted. Five especially late-blooming selections, G-46, L-451, L-272, L-265, and M-209, were selfed as well as intercrossed.

Two outstanding interspecific selections of A. montana x A. fordii F_2 open-pollinated seedlings, BR-351 and BR-413, showing the extended blossoming habit of A. montana have not yet yielded seed but self-pollinations of 14 other such selections have produced almost 800 seeds for planting and evaluation. Oil content of fruit from some of the better hybrid trees was almost 25%. Approximately 10,000 seedlings will be evaluated for the A. montana fruiting habit during 1963.

Breeding for oil content. Three selections having high oil content, L-423, L-426, and M-154, were selfed and intercrossed and yielded 371 seeds which will be planted and evaluated for their oil production. Some selections developed as leaf-spot resistant in a concommitant breeding program are also characterized by high oil content.

Breeding for disease resistance. In the program to develop varieties resistant to the currently devastating angular leaf spot caused by Mycosphaerella aleuritidis, selfing of three clones highly resistant to the disease, F-542, F-554, and M-142, has produced almost 500 seeds, and selfing of 13 clones selected for combined leaf-spot resistance and high-oil content produced almost 700 seeds, for planting and evaluation.

Polyploidy and mutation induction. Aqueous solutions of colchicine were systematically and repeatedly applied to lateral buds on 1-year-old trees. Resultant mosaic patterns on leaves of developing shoots suggested colchicine penetration but permanent tissue changes were not indicated. In a nursery planting of 300 trees propagated from gamma-irradiated buds, eight apparently mutant shoots were found and will be further evaluated. Seedlings produced by self-pollination, with gamma-irradiated pollen, of Isabel and Lampton varieties are being evaluated for apparent mutations and genetic effects.

B. Diseases

1. Safflower. Increased resistance to Phytophthora root-rot. Greenhouse and field studies have resulted in selection of several plant introductions that have a much higher level of resistance to Phytophthora root-rot than any previous line or variety. Some of these have been used in crosses looking toward improved varieties while others are being evaluated for their agronomic characteristics. Increased resistance in safflower lines should help overcome some of the problems of growing safflower as an irrigated crop.

New races of safflower rust. Previously rust-resistant line U-1421 has become more susceptible each year since its selection in 1959. Greenhouse studies with nine field collections of spores on 12 rust differentials indicate that at least two new races will attack U-1421. Selections are available with resistance to the new races, but are agronomically poor lines.

Fusarium wilt identified as safflower disease. Fusarium wilt was found in several fields of safflower in California in 1962. The organism was isolated and identified as Fusarium oxysporum Schl. f. sp carthami n.f. on the basis of its selective pathogenicity. N6 appears to be the best source of resistance to this disease at the present time and crosses have been made to attempt to transfer this resistance to the Gila variety. A simple method of screening for resistance has been found. The disease is seed-borne.

A mosaic-causing virus was isolated from safflower and identified as cucumber mosaic virus. Green peach aphid was demonstrated to be a vector. Of the commercial varieties tested, none was found to be resistant. CMV has been suspected in safflower plots for several years.

Greenhouse studies indicate that several species of Phytophthora will attack safflower. Those demonstrated to be pathogenic on N10 were P. cactorum, P. parasitica, P. erythropseptica, and P. colocasiae.

Alternaria leaf-spot damages commercial safflower. For the first time, Alternaria leaf-spot was a severe disease on nonirrigated commercial safflower production in the Great Plains area in 1962. Although the Montana area had some of the highest yields ever recorded for the state, this disease was estimated to have reduced the potential yield by 20 to 50%. Extended periods of rain and high humidity are necessary for onset of the disease in epiphytotic proportions. None of several genotypes growing in the area were resistant although some lines appeared to be slightly less susceptible than others.

Marked differences were noted in greenhouse tests on safflower heads inoculated at intervals from 1 to 21 days after bloom. Early infections

result in aborted seed only while late infections have little, if any, effect on the seed. Field data indicate a varietal difference to light infections of this disease.

2. Peanut. Susceptibility to stem rot varied among types of peanuts. In continuation of a study at Holland, Virginia, of comparative susceptibility of different types and varieties of peanuts to stem rot, caused by Sclerotium rolfsii, striking differences were found among the major types of peanuts with certain detectable but less striking differences among varieties within the Virginia group. The Valencia type, showed the greatest susceptibility, followed by Spanish, with typical Virginia type peanuts showing least infection but still giving 30 to 50% increases in yield when stem rot was controlled. However, the precision application of simple comparatively inexpensive cultural practices effectively controlled stem rot and increased the yield and market quality of pods of even the most susceptible varieties, thereby obviating the necessity for use of chemicals to control this destructive disease.

Cultural procedures used to control stem rot were deep burial of surface trash in initial land preparation and weed control that resulted in no soil being thrown around the base of the plants during their development. An outstanding additional advantage from use of precision deep coverage of organic debris in initial land preparation has been a consistent striking reduction in weed populations. Results of this study are being prepared for a major technical publication, which will terminate this phase of the study of stem rot in Virginia.

Cause of pod rot is being studied in Virginia. An intensive search for the probable cause of pod rot, the most destructive disease of peanuts in the Virginia-Carolina area for which no control is known, continued at Holland, Virginia, with the use of pesticides known to be specific for control of certain classes of microorganisms. In contrast to results with similar pesticides in 1961, which indicated that a Pythium sp. was probably an important pod rot pathogen, results indicated that in 1962 the primary pod rot pathogen must have been a Rhizoctonia sp. This suggests that pod rot of peanuts in Virginia is a complex problem, and that much additional research will likely be required to determine its cause and to develop practical procedures for suppressing development of the disease under field conditions.

Information is being sought on peanut rust. Peanut rust, which is of negligible importance to growers but is of increasing concern to peanut pathologists and other peanut production research scientists primarily because we know so little about it and it continues to show up sporadically from time to time, was present in Martin County, North Carolina in 1962, the second year the disease has appeared in the Virginia-Carolina area. Exploratory investigations and observations indicate that the Federal Experiment Station in Puerto

Rico, would be a suitable place to study peanut rust and to screen our extensive and constantly increasing peanut germ plasm for possible resistance to rust. Possibilities of taking advantage of this opportunity are being explored.

Plant residues may influence development of Sclerotium rolfsii. In continuing laboratory studies at Auburn, Alabama, to determine the comparative influence of 5 undecomposed plant residues on the growth of Sclerotium rolfsii and Trichoderma viride, corn and oat extract suppressed mycelial growth of S. rolfsii, but promoted moderate mycelial growth of T. viride. Corn and oat solid residue incorporated in soil-sand cultures was highly favorable to T. viride spore production. The moderately high growth potential and high spore production of T. viride on media with corn and oat extract and residues and the known antagonism of T. viride towards S. rolfsii may be factors in reducing the pathogenic potential of S. rolfsii in the presence of such plant residues.

3. Flax. Pasmo and anthracnose cause losses in flax. A severe epiphytotic of pasmo and anthracnose in the South Central part of the spring flax region reduced both yields and quality of flaxseed produced this past season. Infection of commercial acreage by wilt or rust has been negligible during the past decade. However, the discovery of a new race of rust that can attack heretofore resistant common varieties has caused concern. The new race of rust is being tested to determine its range of virulence.

Allelic relationship of rust-conditioning genes. Studies of the allelic relationships of the rust-conditioning genes of flax have shown that genes designated as lying in the M and N loci are not alleles but rather very closely linked genes. As a result of rare crossovers, Bison lines have been recovered that possess either two different M genes or two different N genes in the homozygous condition. No crossing-over has been detected, (among several thousand backcross progeny) between genes designated as lying in the L or the P loci. Consequently, L and P genes are considered as being in two allelic series.

The rust reaction of 450 recent foreign introductions was determined by testing them against races 1 and 22. Several accessions had plants that were resistant to race 22, a race of wide virulence. These plants are likely sources of new genes for rust resistance.

The incubation period of aster yellows virus differed in selected lines of flax. A long incubation period is considered a form of resistance to this virus. No selections of flax have been found that possess sufficient resistance to assure protection from aster yellows virus.

4. Castorbean. Control of capsule-drop. MW-1 and B-296 varieties of castorbeans are more resistant to the mold causing capsule-drop than any other variety or line tested. At Stoneville, Mississippi, MW-1 lost less than 1 percent of its capsules from this disease. Losses for B-296 ranged from 5 to 40 percent. Crosses have been made using MW-1 or B-296 as one parent with a desirable commercial variety as the other parent. Crosses between MW-1 and B-296 have been most resistant to capsule-drop, but other crosses using only one of the resistant varieties have produced resistant progenies. Desiccation of adapted varieties before capsule-drop develops has allowed harvest of a satisfactory crop without serious loss.

Two widely grown inbred varieties, Hale and Lynn, are resistant to Alternaria leaf-spot. Hale Hybrid (Hale × B-122) is rated as intermediate. Capsule molds were prevalent on Hale, Hale Hybrid, Dawn, and Lynn in the Plainview, Texas area, and caused some loss from light seed. Near Crystal City, Texas the loss from capsule molds was estimated at over 50 percent.

Castorbeans appear to have some resistance to Verticillium wilt, since plantings on fields known to be heavily infested have done well. There was some indication that a previous crop of castorbeans may suppress Verticillium wilt in cotton. In 1960 part of a field was planted in sesame, the remainder in castorbeans. Cotton was grown on the field in 1961 and 1962. In 1962, Verticillium wilt of cotton averaged 24 and 8 percent, respectively, on those portions of the field planted to sesame or castorbeans.

Oxidation of phenolic compounds controls resistance to Botrytis. Enzyme assays of isolates of Botrytis ricini from Maryland and Florida showed the fungus produces hydrolytic enzymes that cause degradation of castorbean capsules. B-296, a resistant variety, had greater antienzymic ability than susceptible varieties. Enzymatic activity was reduced by oxidation of capsule pericarp extracts by aeration or by addition of H_2O_2. B-296 had greater oxidizing potential than the susceptible varieties. Resistance is related to the state of oxidation of phenolic constituents in capsule pericarp tissue. A test was developed for rapid determination of resistance or susceptibility of individual plants by means of enzymatic reaction on capsule pericarp tissue.

5. Sesame. Resistance to Fusarium wilt in sesame. Fusarium wilt of sesame could become a serious disease although it is not known to be a problem at present. A fusarium wilt nursery was grown on wilt-infested soil at Clemson, South Carolina in 1962. Thirteen out of 84 strains tested were free from visible signs of the disease. The other 71 strains varied from 1 to 98 percent wilted plants. While dehiscent strains were, as an average, more susceptible than the indehiscent strains, there were good lines in both types suitable as breeding material.

Control of bacterial leaf-spot. Control of bacterial leaf-spot by seed treatment with a volatile mercury compound did not appear feasible from field plot tests at Beltsville. Low dosage rates failed to control the bacterium and high dosage rates caused marked retardation in seedling growth. The most practical method of control is to produce planting seed free from the bacterium in an arid section with a minimum of irrigation, crop rotation, and sanitation of handling and planting equipment.

The effect of amount and source of nitrogen on resistance to both Pseudomonas and Xanthomonas was studied in a growth room. Results indicate that resistance to Pseudomonas and susceptibility to Xanthomonas are expressed only at very low nitrogen levels. Source of nitrogen had little effect on reaction to Pseudomonas, but a marked effect on Xanthomonas in some tests. KNO_3 or $(NH_4)_2SO_4$ inhibited Xanthomonas more than NH_4NO_3 when applied at equal nitrogen levels.

6. Tung. Mycosphaerella angular leaf-spot. During 1962, there was general but mild incidence of leaf-spot because of extremely dry weather during spring and early summer coupled with a light tung-nut crop. Leaf-spot, however, was noted to be somewhat more severe in those orchards, and particularly the Lampton variety, which escaped winter's cold damage. Etiological studies of Mycosphaerella aleuritidis in field and greenhouse showed the incubation period of primary infections was shorter in humid conditions, ranging from 26 to 33 days, than in dry conditions in which the incubation period ranged from 37 to 44 days. Cultures of the leaf-spot fungus taken from tung leaves were generally more pathogenic on both leaves and fruits than were cultures isolated initially from fruits. Fruit infection caused slightly lowered oil content, compared with non-infected fruit, which suggests fruit infection as an important aspect of the Mycosphaerella problem. Fruit of the Isabel variety was particularly susceptible to the disease. The value of leaf-spot control by cultivation-sanitation, reported in 1961, was verified in a commercial orchard of the Lampton variety. The incidence of leaf spot on greenhouse-grown seedlings planted in the orchard, as well as on terminal growth of established orchard trees, was threefold as great in uncultivated as in cultivated areas. Application of oil at as much as 18 gallons per acre to uncultivated orchard floor was ineffective in controlling primary infection. Sanitation studies are being augmented to include the timing relationship of ascospore discharge with oil applications and cultivation.

Bordeaux and Cyprex fungicides gave better leaf-spot control than glyodin and phygon when applied in aqueous solution with a mist blower at the rate of 15 gallons per acre. As in 1961, phygon was phytotoxic. When Cyprex and glyodin were incorporated in oil or in oil-water emulsions, they failed to enhance control over that of oil

used alone. These results are similar to those experienced previously with Maneb, Captan, and Phygon.

Correlation of soil mineral status and infection indicated a close relationship between disease severity and nutritional levels: either low soil calcium or low pH was associated with increased severity of leaf spot.

Mycosphaerella ring-spot: In 1960 a new leaf spot was observed on seedlings of Aleurites fordii being grown in experimental plots in Mississippi. The disease was named ringspot because of its characteristic foliar symptom. The causal organism was identified as the cercospora stage of Mycosphaerella websterii Wiehe, endemic to Africa and Asia, following completion in 1962 of mycological comparisons of Mycosphaerella aleuritidis and M. websterii. The disease has not been seen again in 1961 and 1962 and the method of its origin in the United States remains unknown.

Minor tung diseases: Of the minor tung diseases, thread blight (Pellicularia holeroga) and brown felt (Septobasidium pseudopedicellatum) have been found generally distributed and moderately severe in close plantings with dense foliage. Black rot (Physalospora rhodina) is prevalent on water suckers and nursery stock, and nut rot (Botryosphaeria ribis) is found occasionally in orchards with dense foliage. Web blight (Pellicularia filamentosa) and bacterial leaf spot (Pseudomonas aleuritidis) are found only on the lower leaves of nursery plants and volunteer seedlings in the orchard.

Occurrence of root rot, caused by Clitocybe tabescens, has increased during the past two years. Dead trees are regularly observed in every orchard, but the disease is most severe in orchards grown on cut-over, jack oak land in the Compass Lake, Florida area.

Descaled, paraffin-coated buds forced in the greenhouse at Cairo, Georgia, developed leaves showing typical symptoms of ragged leaf, a common malformation of the early leaves for which no adequate explanation is yet available.

Nematodes: In a cooperative survey with the U. S. Department of Agriculture Nematology Laboratory in Baton Rouge, Louisiana, parasitic nematode genera have been found in soil samples taken throughout the Tung Belt but none serious enough to cause any root damages.

C. Varietal Evaluation

1. Safflower. No new varieties have been developed during the past year. A number of breeding lines have been tested in comparison with present commercial varieties. Several lines appear promising and if performance holds up in further tests, new varieties should be ready

for release in a short time.

2. Peanut. Florigiant shows high yield potential and wide adaptation. Results of 20 cooperative regional peanut variety tests conducted in 9 States in 1962 indicate that Florigiant and other advanced breeding lines of the large-seeded Virginia type from Florida have high yield potential under a wide range of test conditions from Virginia to Florida, and that Starr is essentially the equal of Argentine in yield as tested in Georgia and Oklahoma and slightly superior to Argentine in Texas.

Exceptionally high yields were obtained in 1962 plantings at Tifton, Georgia, where 22 varieties and strains, including the commercial varieties Argentine, Spanette and Florigiant, produced at the rate of more than 5000 pounds of pods per acre, with 84 varieties and strains exceeding 4000 pounds per acre. Timely application of irrigation water during extended periods of acute soil moisture deficiency helped to insure these unprecedentedly high yields at Tifton.

Peanut introductions from foreign countries showing promise. Peanuts are introduced from foreign countries for use in breeding and genetic studies and for evaluation for suitability for production in this country in their present form. Some 1750 recent introductions or selections therefrom were in various stages of evaluation at Beltsville, Maryland, and in cooperative tests in 6 States in 1962. Of some 960 in replicated variety tests at Headland, Alabama, and Clovis, New Mexico, nearly 14 percent exceeded standard commercial check varieties in yield.

P. L. 480 study of range of variability in chemical composition of peanut germ plasm. A P. L. 480 research project has been negotiated with India for a comprehensive cooperative study to determine the range of variability in chemical composition of diverse peanut germ plasm from India and the United States, with the long-range objective of developing highly productive peanut varieties with enhanced nutritional qualities and other attributes that will increase the market demand for peanuts for both food and industrial uses; and to obtain some measure of the effects of seed maturity and different climatic and soil conditions on the composition of different varieties. For 1963 the United States and India have exchanged seedstocks for observation with the expectation that the project will be fully activated in 1964.

Exploratory chemical analyses of U. S. Entries for this study indicate that an appreciable range in composition subject to genetic control exists in protein, oil, linoleic acid, and in total oil and protein combined. Although oil and protein tend to be negatively correlated, exceptions to this relationship have been found.

3. Flax. Caldwell resistant to cold; Arny susceptible to rust. The cold-resistant variety, Caldwell, has demonstrated its merit by survival under winter cold in Southern Texas that destroyed plantings of varieties not resistant to cold. The variety Arny developed for the North Central States suffered less damage from pasmo than most other varieties. Part of the better performance of Arny was due to stiffer straw and less lodging than other varieties, and part due to field resistance to pasmo. However, the new race of flax rust identified in 1963 attacks Arny and the variety may not be suitable for commercial production.

4. Castorbean. At Lubbock, Texas the best F_1 hybrid castorbean outyielded the best inbred by nine percent. At Davis, California the best F_1 hybrid yielded 19 percent more than the best inbred.

Tests of varieties over a wide area show that the oil percentage of the seed of any variety tends to hold the same relative position with regard to other varieties. This suggests selection of hybrids for oil content at one location may be adequate.

5. Sesame. Data were received from 27 yield trials over the area where sesame might be grown. Oro continued to produce the highest average yield. Its mean yield at 26 locations was 969 pounds per acre. SI-155, a new very large-seeded line, produced high yields in tests in Mississippi, Florida, Oklahoma, and Texas where the season was favorable for late-maturing types.

6. Sunflower. Yield tests designed to compare experimental hybrids with high-oil introductions from the USSR were grown in Arizona, Kansas, Nebraska, Minnesota, Texas, and Utah. Highest yield was produced by the experimental F_1 hybrid T-56002. Highest oil percentages were produced by the introduced varieties.

7. Tung. Availability of a variety that will escape most late spring frosts is essential to the tung industry. Pending the development of such a variety through breeding or induced mutation, horticulturally acceptable varieties that bloom at least 8 days later than the current Isabel variety are being sought. Twenty clones with records of late blooming or frost-damage escape have been selected and are being evaluated. Variety evaluation for disease resistance and nut oil-content are integral parts of breeding and disease control programs.

D. Culture and Physiology

1. Safflower. Defoliation study. The removal of all leaves from the lower half of the safflower plant had no significant effect on seed yield, weight per 100 seeds, oil percentage, or bushel weight. Removal of all leaves from the top half of the plant reduced yield more than removal from the lower half, while removal of all leaves

except bracts resulted in the greatest yield reduction. The data indicate that firing or rust on lower leaves may not reduce yield materially.

Date-of-planting. Oil content of the seed was not affected materially if planting was done within normal dates for the area. Yield of seed was decreased materially by planting outside the recommended dates. Data from a trial at Mesa, Arizona, indicate that oil percentage of the seed is not affected unless the growing season is less than 90 days. Yield of seed was reduced by planting after November. Branching, plant size, number of heads, and number of seeds per head are reduced by planting after the optimum date. An increase in planting rate may partially compensate for reduced performance of individual plants.

Weed control. Studies in the Nebraska panhandle show that satisfactory weed control generally can be obtained if cultivation with a rotary hoe is possible two days before the safflower seedlings emerge. The use of an herbicide in connection with rotary hoeing has been effective although most of the control is attributable to the rotary hoe. In a preliminary test at Scotts Bluff, Nebraska only one herbicide treatment out of 30 produced as much seed as the handweeded check. Ten treatments produced yields significantly better than the untreated check. All yields were low in 1962, but the 10 treatments that yielded significantly more than the untreated check averaged only 101 pounds more seed per acre. Such increases are not sufficient to pay the cost of the herbicides.

2. Peanut. Close rows failed to increase yield of peanuts in Alabama. Neither close rows nor heavy seeding in the drill resulted in significantly higher pod yields for Virginia Bunch 67, Early Runner and Virginia Runner G26 peanuts in a study at Headland, Alabama, in 1962 when rows were 12, 24, and 36 inches apart and seeding rates in the drill were 3, 4.5, and 6 inches.

Immature peanut seed were more subject to viability and flavor impairment during curing than mature seed. Curing of green immature seed of Virginia Bunch 67 and Early Runner peanuts at a temperature of 95°F. or higher at Beltsville resulted in impaired seed viability and an obvious off-flavor in seed in sharp contrast to green mature seed of the same varieties which suffered no viability or flavor impairment when cured continuously at 95°F., thereby confirming results of earlier studies at Beltsville and elsewhere that green immature peanut seed are more sensitive to viability and flavor impairment during curing than are green mature seed.

P. L. 480 study of physiology of cell particulates of peanut is under way. A P. L. 480 research project has been negotiated with India for physiological studies on the cell particulates separated by

ultracentrifugation from the tissues of roots and leaves of peanuts grown in normal, saline, and alkaline soils. In preliminary studies, mitochondria isolated from hypocotyls of 7-day old peanut seedlings have been studied; mitochondria have been isolated from roots of 50-day old plants; respiration of root tips of plants grown for periods of 20 to 50 days was measured; and peanut seeds of 4 varieties have been planted in soil and sand for studies on the effect of induced salinity and alkalinity.

3. Flax. Fertilizer trial. A study was continued for the second year in which 5 flax varieties were grown at 3 levels of nitrogen under 2 herbicide treatments. Yield increases of 3.8 and 5.7 bushels per acre resulted from application of 40 and 80 pounds of nitrogen per acre, respectively. Oil percentage and iodine value were decreased by nitrogen fertilization. However, the yield of oil per acre increased. Although herbicide treatments differed in their control of weeds, the mean seed yields of the treatments were not significantly different from each other or from the untreated check.

Physiologic studies. Day temperature and nitrogen level were found to affect flax growth. Increased temperatures hastened stem and boll maturity. When the nitrogen supply in the nutrient solution was limited to 28 ppm or less, there was a marked decrease in height, dry weight, and boll production. Nearly normal growth resulted when the N level was 112 ppm.

The composition of oil in flaxseed was found to be affected by temperature, light intensity, and daylength, but not by drought. High temperatures at night or during the entire 24 hour cycle caused virtual cessation of synthesis of polyunsaturated fatty acids in developing flaxseeds. Long 20-hour days at 20°C hastened maturity and increased iodine value. Short 8-hour days also increased iodine value in comparison with plants grown under standard 16-hour days.

Seed grown under 1000 ft.-c of light was about 20 points lower in iodine value and 10 percentage points lower in linolenic acid than seed grown under 2500 ft.-c of light. Significant changes in oil composition could not be detected when water availability was varied from 0.3 atmospheres to 3.3 atmospheres.

Incorporation of C^{14}-labeled acetate into seed fat *in vitro* was successfully demonstrated. Conditions which were found to favor incorporation included light, pH 6.0, age 20 days or younger, and inclusion of biotin in the medium for embryos 15 days of age or younger.

A procedure for extracting and measuring all the lipids present in germinating flax seeds was developed. Chloroform and methanol in a ratio of 2:1 was used as the extracting solvent. The lipid extract was chromatographed on a thin layer of Silica Gel G. The free fatty

acids were eluted from the gel and determined colorimetrically. Phospholipids were determined by measuring the amount of phosphorus present in the crude lipid extract. Triglycerides were analyzed by colorometric procedures following oxidation with silver dichromate or sulphuric acid.

Changes in percent lipids in germinating seeds of B-5128 were determined over a 65-hour germination period. The percent of total lipid decreased continually during the period. The percent of phospholipids decreased at the 19-hour interval but then increased at the 40- and 65-hour intervals. There was a noticeable increase in free fatty acid at the 65-hour interval.

4. Castorbean. Fertilizer trials. The incidence of Alternaria leaf-spot decreased with increased rates of nitrogen applied to Baker 296 at Goodwell, Oklahoma. The seed yield from the highest rate, 200 pounds of nitrogen per acre, was significantly higher than the other nitrogen treatments. Oil content, test weight, and seed weight were not influenced by treatment or incidence of the Alternaria leaf-spot organism. At Lubbock, Texas, yields were not different in a variety-water-fertilizer test. Lack of response to moisture levels was attributed to 15.58 inches of rainfall during the growing season. Less irrigation water was required at Lubbock to produce economic yields with a skip-row planting (2 planted, 1 skipped) irrigated only between the 2 planted rows than with a solid-planting irrigated between all rows; however, the latter is recommended when plentiful water is available. In a fertilizer trial on sandy soil irrigated with sprinklers at Seminole, Texas, Hale and Hale Hybrid showed good adaptation with average yields of 2122 and 2465 pounds per acre, respectively.

Weed Control. Diuron, [3-(3,4-dichlorophenyl)-1,1-dimethylurea], and amiben, (3-amino-2,5-dichlorobenzoic acid), were evaluated as preemergence herbicides using the variety Baker 296 planted at 1-, 2- and 3-inch depths at Stoneville, Mississippi. Amiben applied at amounts up to 4 pounds per acre did not cause injury at any of the planting depths; excellent weed control was obtained at 3 pounds per acre. Diuron gave good weed control at 1 pound per acre; however, extensive reductions in stand resulted at the 1-inch planting depth with minor reductions at the 2-inch depth.

Desiccation and early harvest minimize loss from capsule drop. Capsule drop is a major problem in Mississippi. Four years of yield results obtained from (1) harvesting test plots more than once during the growing season, (2) from a date of desiccation test, and (3) from date-of-harvest tests indicate that by desiccating and harvesting in late September or early October yields of certain varieties should not be reduced appreciably. This may be a successful method of producing castorbean in the Mississippi Delta until

varieties resistant to capsule drop become available. Two years of data from a date of defoliation test at Davis, California, suggest that defoliation should not be done before September 15th and that there is no significant gain in yield, test weight and oil content by defoliating after October 1.

5. Sesame. Direct combining of indehiscent sesame. Hand-threshed seed from three indehiscent lines (SI 128, SI 139 and SI 151) harvested at Lubbock, Texas, after physiologic maturity but before a killing freeze had an average germination of 99.0%. Seed from plants in the same experiment, which were windrowed at physiologic maturity or left standing, were harvested January 22 after numerous early light frosts and severe freezes in late December and January. Seed from windrowed plants had an average germination of 89.6% while seed from standing plants germinated 96.0%. Reduced average germination of seed from windrows can probably be traced to deterioration of seed in capsules in contact with the soil. These data are in direct contrast to previous reports of severe seed damage as measured by loss of germination and oil becoming rancid when physiologically mature plants were killed by a sudden hard freeze. It would appear that light frosts killed the standing plants in this experiment without formation of ice crystals within the seed, and seed were dry before a severe freeze occurred.

A study was conducted at College Station, Texas, to compare the root systems of 4 dehiscent strains at physiologic maturity. Plants of SI 32, a very early-maturing Early Russian selection, produced the smallest taproot and the smallest number of lateral roots. Plants of SI 36, a relatively early-maturing drought resistant line, produced the most extensive root system both visually and as determined by total number of lateral roots. SI 153, which is of intermediate maturity, produced the longest lateral roots. The late-maturing large-seeded line, SI 155 had the largest diameter of taproot at the crown.

Weed control. Previous studies indicated that sesame may possess high tolerance to the herbicide CIPC [isopropyl N- (3-chlorophenyl) carbamate]. Treatments of 0, 4, 8, 10, 12, 24 and 36 pounds per acre of CIPC were applied to sesame at Stoneville, Mississippi. All CIPC treatments provided good weed control but all stands of sesame were extremely poor, and plots were not harvested. CIPC continues to serve as the standard check in the pre-emergence weed control test at Florence, South Carolina; however, a new formulation Hercules #75 31-80% W.P. gave superior control of crabgrass, pigweeds and other broadleaf weeds. Several other materials show enough promise to warrant further testing.

Two regional yield tests were grown under similar conditions at Stoneville, Mississippi, except that one test was grown on 20-inch rows and the other on 40-inch rows. Mean yield of all entries in the test

grown on 20-inch rows was 1998 pounds per acre compared to a mean of 1347 pounds per acre for the 40-inch row test. Use of narrow rows seems to be an excellent method of controlling weeds as well as increasing yields in sesame.

6. Tung. Temperatures as low as 7°F. occurred in the western part of the Tung Belt in January 1962 and as low as 6°F. in many parts of the Tung Belt in December 1962. Again in January 1963, similar temperatures were experienced. The January 1962 temperatures caused much damage in orchards that had overproduced in 1961 or had received inadequate fertilization or cultivation. Trees growing on unsuitable soil types or ones suffering from root rot were killed or severely damaged Similar damage is to be expected from the December 1962 and January 1963 low temperatures, though the extent of the damage should be less because of the elimination of weak trees in 1962. The severe winter of 1962, with resultant crop loss, precluded most results in the following research areas: effect of tree spacing on yield; the effect of ratio of staminate and pistillate flowers on yield, and methods to control sex ratios; the effect of moisture stress on oil content of the fruit; and the mineral nutrition studies on tree growth and yield.

Dormancy: With the possible exception of a very few trees, tung has no or a very low cold requirement; given a long enough warm period, tung buds which have had little or no exposure below 45°F. can be forced into growth, particularly if the bud scales are removed. In general, the longer the period of continuous or of cyclic cold, the shorter the continuous warm period required to force the buds into growth.

Descaled buds on cut terminals blossom earlier than buds not descaled. Bud scales inhibit development of flowering. The effect may be more pronounced in the fall than in the winter or spring indicating some effect from cold exposure.

Buds forced in the greenhouse until the bud scales began to separate developed rapidly after being placed out of doors on January 30. It would appear that outdoor temperatures from January 30 to February 19 were sufficiently cool to retard opening of dormant buds but not cool enough to halt growth of buds that were already actively growing.

Conditions of almost continuous total darkness decreased the rate of development of descaled buds on cut terminals. This suggests light as a factor in bud growth. Removal of the protective bud scales hastened bud growth. If light is a factor in bud growth, bud scales may function in blocking out light. Descaled buds sealed in clear plastic were less active than those not so treated suggesting that bud activity may be somewhat dependent upon adequate aeration as bud scales may tend to restrict free exchange of gases.

Soil Management: Effects of soil management and fertilizer level were reflected in the differences in crop loss resulting from the freeze of March 6, 1962, at Agricola, Mississippi. Yield of plots with crimson clover crop, later cultivated 3 or 4 times, and with a high level of fertilizer was 0.5 ton/acre compared to no crop on Bahiagrass plots with a low level of fertilizer, regardless of cultivation. Increased cultivation did not increase yield of trees in either crimson clover or Bahiagrass. Average over all yield/acre was 0.32 and 0.05 tons, respectively, for plots receiving high and low fertilizer levels. Oil content of fruit was significantly higher in fruit from trees receiving high, rather than low, fertilizer applications. Effect of soil management on oil content of fruit was erratic. The detrimental effects of Bahiagrass on growth and yield of mature tung trees, even at high levels of fertilizer, emphasize the risk taken when extra grazing is provided at the expense of good culture.

Weed Control: Bermuda-grass sod in young tung orchards reduces tree growth and yield and is difficult and expensive to control by mechanical means. At Lucedale, Mississippi, two applications of dalapon at 5 pounds/acre or combined with 4 pounds simazine or 1.5 pounds 2,4,5-T in 1961 killed the above-ground parts of Bermuda-grass. By June 1962, 28 percent of the area treated with dalapon plus simazine and 35 percent of the area treated with dalapon alone was reoccupied with Bermuda-grass, whereas 98% of the check area was occupied. Total linear growth of tung trees tended to be directly related to the degree of reduction in Bermuda-grass. At Compass Lake, Florida a single application of dalapon kept Bermuda-grass under control and resulted in better leaf color, increased trunk cross-sectional area and terminal growth of tung trees. Response to fertilizer was greater where sod was kept under control by the use of herbicide.

Growth regulators: Maleic hydrazide, a plant growth regulator known to delay somewhat the blossoming of tung when applied in the orchard, was found to affect the growth of tung seedlings and germinating tung seed. Growth was inhibited in proportion to the amount applied. Other chemicals tested, such as Phosphon (2,4-dichlorobenzyltributyl phosphonium chloride), CCC (2 chloroethyl-trimethyl ammonium chloride), and CO-11 (N-dimethylaminomalcamic acid) had little value as growth retardants applied to tung seed.

Blossoming of tung twigs that had been cut in the fall from mature trees and held in a refrigerator for several months prior to removal for experimentation was inhibited in proportion to the amount of maleic hydrazide applied. Concentrations strong enough to delay blossoming materially tended to be lethal. Those weak enough to cause no major injury failed to delay blossoming for the desired length of time. Potassium gibberellate and thio-uracil provided similar experience.

Results obtained with maleic hydrazide and other chemicals indicate

that chemicals can be screened quickly and easily for toxicity, growth inhibition and effective levels by using tung seed, young seedlings or cut terminals.

Biochemistry of oil synthesis: The carbohydrates stored in the tung kernel at the time of initiation of oil synthesis are insufficient to account for formation of all of the oil which ultimately accumulates. Thus one of the first steps toward an understanding of the oil synthesis process is the study of the biochemical changes occurring in the tung kernel at the initiation of oil synthesis. Biochemical studies indicate a radical change in endosperm metabolism associated with oil formation. Prior to the synthesis of oleosteoric acid, a primary tung-oil constituent, the endosperm contains a lipid fraction probably associated with metabolic functions of the endosperm cells. This information is interpreted as indicating that oleosteoric acid synthesis occurs in the endosperm from precursors translocated into the endosperm.

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WEED AND NEMATODE CONTROL
Crops Research Div., ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has been long known that severity of attack by certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on oilseeds and peanuts.

USDA PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups, and is cross commodity in nature. The total weed control program involves 66.5 professional man-years' effort. Of this total 1.8 is specifically directed to weed control in oilseeds and peanuts at Stoneville, Mississippi; Tifton, Georgia; and Beltsville, Maryland. The Federal scientific effort devoted to basic and applied nematode research is 21.5 professional man-years, of which 2.9 is devoted to applied research in oilseeds and peanuts at Auburn, Alabmaa; Tifton, Georgia; and Jackson, Tennessee.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Weed Control.

a. Soybeans. In weed control studies in soybeans at Stoneville, Mississippi, prometryne, 3-amino-2,5-dichlorobenzoic acid (amiben), and linuron continued to provide good to excellent preemergence weed control in soybeans at rates that caused no crop injury. These herbicides provide much better control on clay loam or clay soils than other herbicides now in use. Postemergence applications of diuron-surfactant mixtures to soybeans provided good weed control with little or no soybean injury. Toxicity of 4-(2,4-dichlorophenoxy)butyric acid [4-(2,4-DB] applied postemergence to soybeans was greater than in prior work at Stoneville.

However, the herbicide still appears promising for the control of cocklebur in soybeans at approximately 0.2 lb./A. Severe early-season soybean injury with 4-(2,4-DB) generally had little effect on soybean yields.

Delapon or cultivation were effective as preplanting treatments for seasonal control of Johnsongrass in soybeans and resulted in greatly increased soybean yields at Stoneville. The ethylene glycol bis ester of trichloroacetic acid (TCA) in oil was equally as effective as dalapon for spot treatment of Johnsongrass. Preliminary results indicated that alternate treatments with different herbicides may be more effective for Johnsongrass control than repeated applications of a single herbicide. Seven herbicides were selected from greenhouse trials for future field evaluation as preemergence treatments for soybeans, and seven other herbicides for postemergence evaluation studies. Promising new preemergence herbicides for soybeans include methyl 3,4-dichlorocarbanilate (swep) at 8 lb/A and N-cyclooctyl-N-dimethylurea plus butynyl N-(3-chlorophenyl) carbamate (alipur) and 3-cyclooctyl-1,1-dimethylurea (cycluron) at 4 lb/A. At State College, Mississippi, linuron at 4 lb/A gave best weed control in soybeans while postemergence application of prometryne either with or without a surfactant was very toxic to soybeans.

b. Peanuts. Herbicide mixtures applied at the emergence stage of peanuts have been used successfully to control crabgrass and Florida pusley (Richardia scabra) in experiments at Tifton and Experiment, Georgia. Seasonal weed control was obtained with the following herbicides and mixtures: DCPA at 4 or 8 lb/A plus DNBP at 3 lb/A, prometryne at 2 or 3 lb/A plus DNBP at 1.5 lb/A, DMPA at 6 or 9 lb/A plus DNBP at 1.5 or 3.0 lb/A, tris(2,4-dichlorophenoxyethyl) phosphite (2,4-DEP) at 1,2, or 3 lb/A plus DNBP at 1.5 lb/A, sodium 2,4-dichlorophenoxyethyl sulfate (sesone) at 2 or 3 lb/A plus DNBP at 1.5 lb/A, and prometryne at 4 lb/A. A mixture of DMPA and DNBP applied preemergence gave seasonal control of annual weeds whereas preemergence applications of sesone or 2,4-DEP mixed with DNBP did not provide seasonal control. The thiolcarbamate herbicide, PPTC, when preplant incorporated offered potential for the selective control of nutsedge in peanuts.

B. Nematode Control.

Oilseeds and Peanuts. Experiments at Jackson, Tennessee, have shown that larvae in eggs of the soybean cyst nematode (Heterodera glycines) in the cyst were no more resistant to heat than larvae in eggs outside the cyst. In both cases all larvae were killed in about 40 seconds at 135°F. and in

8 minutes at 125° F. Hatched larvae were much less resistant to heat; all were killed in less than 5 seconds at 135° F., and in one minute at 125°.

In addition to root damage, the soybean cyst nematode (Heterodera glycines) also interferes with nitrogen nodulation of soybeans. Experiments at Jackson, Tennessee have shown that nodulation returns to normal when the soybean cyst nematode is controlled by soil fumigation or crop rotation.

Experiments at Tempe, Arizona have shown that although safflower is highly susceptible to both cotton and Javanese root-knot nematodes (Meloidogyne incognita acrita and M. javanica), it generally escapes damage in Arizona field plantings because safflower is planted when the soil temperature is too low for nematode activity.

Sheath nematodes (Hemicycliophora spp.) may be a serious pest of peanuts. Tests at Auburn, Alabama demonstrated that these nematodes suppressed lateral root growth of peanut seedlings, and also produced lesions which can be invaded by fungi.

In experiments at Auburn, Alabama, the effect of two different populations of the "peanut root-knot nematode" (Meloidogyne arenaria) on peanuts was compared. One population was well adapted to peanuts, caused formation of normal galls, and reproduced freely. The other population was apparently poorly adapted, caused very small galls and reproduction was very much limited.

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SOYBEAN AND PEANUT INSECTS
Entomology Research Div., ARS

Problem: Soybeans and peanuts are severely damaged by several insect pests in the different areas where these crops are grown in the United States. The increasing concentration of acreage in soybeans and possibly the adaptation of native insects to this crop are resulting in more varied and more serious insect problems. In the absence of specific support for research on soybean insects, some shifts in emphasis have been made to investigate some of the problems. However, basic information is lacking on the biology of many of these pests and on the extent and nature of damage they cause to these crops. Such information is needed to serve as a foundation for the development of satisfactory control methods. Some insecticides, although highly effective in controlling insects on soybeans and peanuts, cannot be used because they leave harmful residues. Further, certain insects have developed resistance to insecticides that are currently recommended. For the immediate future, there should be continued effort to find insecticides that can be used safely and that give effective, economical control of all species of insects attacking these crops. For more desirable long-range solutions to the problems, more attention needs to be given to nonchemical control methods, with particular emphasis on insect-resistant crop varieties and biological control agents and the exploration of new chemical approaches such as attractants and repellents.

USDA PROGRAM

The Department has a limited program involving basic and applied research on the insect problems of peanuts and soybeans directed toward developing efficient and economical control methods. The program is cooperative with State and Federal entomologists, agronomists and chemists. Studies on soybean insects are conducted at Columbia, Mo., and on soybean and peanut insects at Tifton, Ga., in cooperation with the Missouri and Georgia Experiment Stations.

The Federal scientific effort devoted to research in this area totals 1.5 professional man-years. Of this number 0.3 man-year is devoted to basic biology; 0.3 to insecticidal control; 0.5 to insecticidal residue determinations; and 0.1 to biological control; 0.1 to varietal evaluation for insect resistance; 0.1 to insect vectors of diseases and 0.1 to program leadership.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic Biology

1. Soybean Insects. Screen cages were utilized at Columbia, Mo., to study the effect of stink bug damage, pod removal, and simulated stink bug punctures on soybean production and maturity. There were no significant differences in the number of pods set on plants in uninfested cages and in cages in which 4 pairs of Euschistus servus stink bugs were present, 8 E. servus male bugs were present, or where pods on the lower half of the plant had been pierced with sterile minuten needles to simulate stink bug injury. Where pods on the lower half of caged plants were removed, the number of pods remained significantly less than in the other treatments. There was no difference in number of damaged beans between treatments containing 8 male stink bugs and simulated damage to the lower half of the caged plants. Cages containing 4 pairs of stink bugs showed a significantly greater damage than all treatments primarily because of reproduction within these cages. The number of undeveloped seeds increased in the treatments in the following order: Pods removed, check, pierced pods, eight male stink bugs, and four pairs of stink bugs.

B. Insecticidal Control

1. Soybean Insects. Results of field tests in Missouri to evaluate the effectiveness of Sevin, Guthion, toxaphene, malathion, and methoxychlor showed no significant differences in yield of soybeans or in the number of damaged beans in any treatment from the check. Lack of concrete results may have been partially due to poor timing of insecticide applications which were made too early with respect to stink bug infestation.

At Tifton, Ga., diazinon, Zectran, Guthion, endosulfan, and Sevin at 4, 8, and 16 ounces per acre, were applied to soybeans which were in a late blooming stage with some pods formed. Counts of Mexican bean beetle larvae and adults and corn earworm larvae were made 5 days after treatment. Diazinon gave approximately 71% control of the Mexican bean beetle. The 16-ounce rate gave 68% control of the corn earworm. Zectran gave 95-97% control of the Mexican bean beetle. The 4-, 8-, and 16-ounce rates gave 65, 93, and 98% control of the corn earworm. Guthion at these rates gave 46, 57, and 96% control of the corn earworm. Endosulfan at 4, 8, and 16 ounces, gave 43, 80, and 85% control of the Mexican bean beetle and 9, 45, and 66% control of the corn earworm. Sevin gave better than 85% control of the Mexican bean beetle at all rates. At 4, 8, and 16 ounces per acre, this insecticide gave 56, 73, and 93% control of the corn earworm.

Granular dieldrin, ethion, Dylox, Bayer 29493, and 4 formulations of Sevin were tested at Tifton for control of the lesser cornstalk borer

on seedling soybeans. The formulations of Sevin were: (1) Water impregnated on vermiculite with a water repellent coat, (2) water impregnated on basic clay with a water repellent coat, (3) acetone impregnated on acid clay without coating, and (4) acetone impregnated on basic clay without coating. All were applied at two pounds per acre. The water impregnated formulations of Sevin were also applied at a one pound rate. They were applied in an 8-inch band over rows of soybeans in the 2-leaf stage. Dieldrin, Bayer 29493, Dylox, and ethion provided effective control of the insect and differences between them were not significant. All Sevin formulations, at the rates tested were ineffective.

C. Insecticide Residue Determinations

1. Residues of Endrin and Chlordane on Peanuts. At Tifton, Ga., peanuts were treated with granular formulations of chlordane at 4 pounds per acre and endrin at 2 pounds per acre. Applications were made at pegging time, July 23, 1962, in a 14-inch band over the row. The peanuts were harvested October 24, and air dried for 2 months. The residues on dried whole peanuts from the chlordane-treated areas averaged 1.74 p.p.m. chlordane and in addition 0.19 p.p.m. heptachlor epoxide. The chlordane granules by analysis contained a small amount of heptachlor, 0.48%, but no heptachlor epoxide was detected. Residues of endrin averaged 0.81 p.p.m.

D. Biological Control

1. Parasites of Lesser Cornstalk Borer. Parasitism of lesser cornstalk borer larvae attacking seedling soybeans and cowpeas may exceed 50% of the larval population. Parasites collected at Tifton, Ga., were Pristomerus pacificus melleus, Orgilus n. sp., and Stomatomyia floridensis.

E. Varietal Evaluation for Insect Resistance

1. Stink Bug. Results of varietal evaluation at Columbia, Mo., of soybeans with respect to damage by stink bugs indicated that differences were principally due to date of maturity rather than other inherent differences in 12 varieties tested.

F. Insect Vectors of Diseases

1. Transmission of "Yeast Spot" of Soybeans by Stink Bugs. In studies at Columbia, Mo., stink bug damage to soybeans resulted principally from the introduction of the yeast, Nematospora coryli, which causes "yeast spot" disease. This yeast was isolated in the laboratory in Columbia in the fall of 1962. Tests with laboratory grown plants proved the capability of this organism to cause the disease. Re-isolation of the organism has been repeatedly demonstrated

in both artificially inoculated and stink bug damaged soybeans. The organism has been isolated from the macerated heads of Euschistus servus and transmitted to soybeans. In cage tests in the field the disease organism was not transmitted through artificial puncturing of the pods but was readily isolated from caged plants and pods which had been associated with the brown stink bug. Both the brown stink bug (E. servus) and the green stink bug (Acrosternum hilare) transmit N. coryli to soybeans.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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PEST CONTROL TECHNIQUES AND EQUIPMENT, HARVESTING, AND HANDLING OPERATIONS, CROP PREPARATION AND FARM PROCESSING
Agricultural Engineering Research Div., ARS

Problem. Many pests attack oilseeds and peanuts resulting in dollar losses to farmers each year. Plant diseases, weeds, insects and nematodes are examples. Every method to control or eradicate any of these pests requires some type of equipment, be it a small chemical sprayer or a giant bulldozer. In many situations, effectiveness of the equipment necessary may be essential to the success of the method which is attempted or recommended. Thus, equipment to control a wide variety of pests on a wide variety of crops is required. There is a need for improved methods of much greater efficiency for applying pesticides to plants and the soil.

Development of equipment and methods for efficiently harvesting and farm handling oilseeds and peanuts, with emphasis on the preservation of inherent qualities during these processes is needed. The cost of harvesting and farm handling of most crops is the major expense of production, often amounting to over half of the total returns to the producer from the sale of the product. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

While research on harvesting equipment and methods has led to much improvement in the reduction of production costs of some crops, much additional work needs to be undertaken, both basic and developmental, in order that all crops may be mechanically handled.

Development of better methods, techniques, and equipment for use on farms for the initial preparation for market or the processing of oilseeds and peanuts is needed to increase efficiency in the use of labor and equipment, preserve quality and prevent spoilage and damage from mechanical handling. While considerable information has already been obtained for the development of processes such as drying and separation, basic and more precise information must be developed for these and other processes before development progress can be continued. The underlying principles that pertain to the cleaning and drying of different crops, curing of

peanuts, and sorting need to be determined. The methods for processing farm crops are largely dependent on production practices and dictated by future handling or storage requirements. Consequently, this requires interdisciplinary collaboration in the creating of a completely mechanized program of crop production.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural engineers, physicists, and mathematicians engaged in both basic studies and the application of known principles to the solution of farmers problems. Pest control research on soybeans is conducted at Columbia, Missouri, and at Ames, Iowa. The research for peanuts is at Holland, Virginia. The Federal scientific effort devoted to research in this area totals 0.8 on soybeans and 0.2 on peanuts.

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Research on oilseeds and peanut harvesting equipment and methods is cooperative with the Experiment Stations at Stillwater, Okla., (castor beans); Bogulsa, La., (tung nut); and Holland, Va., (peanuts). The Federal engineering effort devoted to research on oilseeds and peanuts harvesting and handling operations and equipment totals 3.4 professional man-years.

The Department's effort in the area of crop preparation and farm processing (except cotton) constitutes a long-term program involving agricultural engineers and statisticians engaged in both basic and applied research on the engineering phases of crop preparation and farm processing. Research on the drying and hulling of tung nuts is conducted at Bogalusa, Louisiana, in cooperation with the Experiment Station and industry. Drying of castor seed is cooperative with the Oklahoma Experiment Station. The Federal engineering effort devoted to research in this area totals 0.4 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Pest Control Techniques and Equipment

Weed Control in Corn and Soybeans.

1. In investigations made in cooperation with the Iowa Station, results from several experiments showed that early spring applications of Atrazine and Simazine on fall plowed, spring plowed, and unplowed ground controlled weeds in corn throughout the season. 2,4-D at 4 lbs. of acid per acre gave good control up to planting time. Although yield and stand differences were not significant at the five percent level, the data showed a slight trend toward improved stands and yields where some tillage was performed prior to planting as compared to no tillage. A rotary tiller that worked a 12-inch strip two to four inches in front of the planter gave better results than a cultivator sweep in front of the planter or disking in front of the planter.

Continued studies in Iowa on comparisons of liquid and granular herbicide formulations applied at planting time in bands over the row and over the entire area showed that liquids were as effective as granules for most herbicides. Atrazine and Simazine were the exceptions, and the results showed that weed control was more erratic with the granular formulations of these compounds. Strip applications were nearly as effective as broadcast; however, it was always necessary to cultivate at least once where chemicals were applied in strips, and only when the chemicals failed was it necessary to cultivate where overall applications were made.

Studies on mechanical cultivations in Iowa showed that harrowing after planting did little to improve stands, yields, or weed control. However, when the rotary hoe was used with 3 cultivations, harrowing after planting showed a slight improvement in weed control. Although three cultivations gave substantially better weed control than two cultivations, stand and yield data showed that two were as good as three. Two cultivations resulted in yields and stands that were as good as or better than various combinations of rotary hoeing and weeding with two and three cultivations. Shallow cultivations with rotary hoes, dragging hoes, and spring-tined weeders improved the weed control but not enough to materially affect yield.

The effect of varying the percentage formulation and rates of active ingredient of granular herbicides was studied in Iowa. All pre-emergence chemical treatments gave better weed control and higher yields than the untreated check. Ten and 20 percent Atrazine were equally effective. Ten and 20 percent formulations of 2,4-D at the 2 and 4 lb./acre rates were equally effective. The 4 lb./acre rate of 2,4-D did not improve weed control and showed no visual evidence of damage; however, yields were slightly lower than the 2 lb./acre rate. The Atrazine formulations gave better weed control than the other chemicals.

Spherical and regular granular formulations of 10 and 20 percent 2,4-D were applied in Iowa with John Deere, Gandy, and Noble boxes attached to an electrically driven cart that operated on a portable track. Distribution as indicated by photographs of granules caught on a plastic sheet showed little or no difference among machines. The number of granules per square inch varied considerably and there was no indication that patterns of spherical and regular granules were materially different. Spherical granular formulations of the 12/20 mesh size gave better weed control than equal amounts of 12/20 regular granules.

A number of commercially available or experimental herbicides were evaluated in Iowa for pre-emergence weed control in corn and soybeans. Atrazine, Randox and Randox T at recommended rates again resulted in best weed control in corn. Amiben and Randox gave the best results in soybeans. Directed post-emergence spray applications of Dowpon and 2,4-D combinations resulted in some crop damage but improved weed control. Similar treatments with Lorox showed promising results.

A study of sampling procedures for estimating yields of mature weed infestations was carried out in Iowa. Precision indices were calculated for various sampling methods involving different fractions of the entire experimental plot. Loss of precision did not exceed 25 percent when as little as 40 percent of the plot was harvested in random segments. These techniques will permit efficient harvesting of mature weed infestations from herbicide tests and crop-weed ecology experiments.

Field studies were made in Missouri to determine the effect of row spacing on Clark soybean yields with and without pre-emergence treatments of Amiben at a rate of 3 lbs./acre. Abnormally high variability caused by uneven soil moisture conditions made the study very difficult to analyze. Because of this high variability there were no significant differences in yields of soybeans due to mechanical or chemical treatments.

Studies of the effect of three tillage methods on three weed control methods were conducted in Missouri for the fifth and last year. Corn yield was significantly lower in plots where the soil was prepared by conventional methods than plots where the soil was prepared by minimum tillage methods. There were no significant differences between any of the three weed control methods; (a) cultivate as needed, (b) pre-emergence 2,4-D and cultivate as needed, and (c) pre-emergence Atrazine. This indicates that the condition or smoothness of the soil surface has no effect on the action of the herbicides as determined under field conditions. The results indicate that a full season chemical weed control program is essential when using minimum tillage methods of soil preparation for corn production.

Field trials to determine the effect of rainfall (or irrigation) on weed control with granular and liquid formulations of 2,4-D were conducted in Missouri for the second year. Early applications of one and one-half inches of water immediately after pre-emergence application increased the weed yield significantly and caused the corn yield to be significantly less than the treatments where no water was applied. The pre-emergence applications of both liquid and dry formulations of 2,4-D suppressed the number of weeds. The corn yield was higher in plots receiving the granular formulation of 2,4-D.

Studies were made in Missouri to determine the effect of directed post-emergence applications of dalapon on corn. Four degrees of leaf protection were employed with two nozzle heights. The leaf protections used were (a) none, (b) leaves tied up, (c) shield leaf lifter, and (d) wire leaf lifter. A mechanical shield type leaf lifter was very effective in minimizing the dalapon damage to corn. Wire type leaf lifters will have to be improved before they can be recommended for this application. Even when maximum protection was used by tying the leaves, there were visual damage to the corn plant, but this did not reduce the yield significantly. With the 3-pound rate of dalapon there was no apparent corn yield reduction when adequate leaf protection was provided.

A special long-boom sprayer was designed and constructed in cooperation with Crops Research Division, Southern Great Plains Field Station, Woodward, Oklahoma. The sprayer was constructed by using the chassis of a used self-propelled combine. A 100 foot boom is supported by a moveable frame in front of the combine. The spray tank was mounted in the center of the combine chassis. Modifications to the combine chassis included (1) moving the engine down and to the rear of the combine, (2) replacing the tires with Air Force B-50 bomber tires, and (3) increasing the tread width to about 10 feet. The sprayer can easily spray an acre per minute and is designed for use in open range areas too small for aerial applications.

A study was made in Missouri to determine the minimum mixing rates for applying several dry-formulation herbicides. A special spray stand was constructed to evaluate the performance of standard sprayer components when applying herbicides at different concentrations. The results of this study indicate that the following herbicides and minimum volumes of application are required for satisfactory sprayer performance when using a jet hydraulic agitator in a 55 gallon tank; Propazine 8 gallons per acre, Atrazine 12 GPA, NaPcP 15 GPA, Simazine 18 GPA and Linuron 20 GPA.

Pest Control Equipment for Peanuts.

1. Weed control in peanut production was accomplished in Virginia without the use of hoeing labor by using DNBP (alkanolamine salt of four to six dinitro-ortho-secondary-bulylphenol). This herbicide applied on a non-rolled drill surface was as effective as on a rolled surface at either nine

pounds (active ingredients) per acre at time of planting or six pounds per acre at emergence. The six pound per acre rate at emergence was as effective for weed control as the nine pound per acre rate at planting. By using split applications of either six or nine pounds per acre at emergence and the same amount applied two weeks after emergence, no hoeing was necessary. When DNBP was used as a pre-emergence or emergence application only, the weed infestation in the drill was reduced to approximately 1500 to 3000 weeds per acre, requiring five to seven man-hours of hoeing labor per acre. The check plots, with no herbicide, had 9,800 to 11,200 weeds per acre and required 10 to 11 man-hours of hoeing labor per acre. Maximum weed control was obtained by the use of DNBP at the rate of nine pounds per acre at emergence and nine pounds per acre two weeks after emergence. The yields of peanuts receiving herbicide applications appeared to be higher than those not receiving herbicide, however, the differences were not statistically significant. This work is being terminated and the several years results will be published.

B. Oilseeds and Peanut Harvesting Equipment.

1. Development and improvement of peanut diggers continued with tests of four different makes of peanut diggers showing that the recovery efficiency was relatively high. Losses by weight of unshelled peanuts salvaged from the soil ranged from 3.0 to 5.7 percent. Some of these losses are due to natural shedding. Peanut plants from which the tops were clipped prior to digging lost significantly more peanuts in the digging operation than unclipped vines.

Methods of accelerating the drying rate of windrowed peanuts consisted of the formation of four different types of windrow: nuts up; clipping vines prior to digging; nuts down; and, the conventional method which results in nuts being mixed in the windrow. For the first 24 hours, the drying rate was about the same for the nuts in each windrow. The peanuts turned up appeared to dry faster from the first to the fourth day, but from the fourth day to the eighth day the drying rate for each type of windrow was approximately the same. Although there was a tendency for a faster drying rate with the peanuts turned up, there was no significant difference of the drying rate of the windrows within any one day or from day to day.

2. Combine harvesting of high moisture peanuts. Combine studies conducted with the Virginia type peanuts to compare grades and recovery yields when harvesting freshly dug peanuts and those combined at 1, 2, 4, 6, and 8 days after digging have shown that recovery yields were not significantly affected by harvesting dates. Although not statistically significant, slightly lower yields were obtained from combining freshly dug peanuts than from harvesting after partially curing them in the windrow. Good recovery yields were obtained beginning as early as the second day after digging.

3. Castor Combine for Harvesting Damp or Dry Castor Beans. Frequent periods of adverse weather (high humidity and wet plants) experienced late in the fall during the castor harvest season results in delayed harvesting and in-

creased field losses using existing harvesters. A four-row harvesting attachment was designed and built for a commercial grain combine which cut off the plants and passed them through the machine for removing the capsules, hulling and cleaning. Over 17 acres were harvested with only minor row losses. Several companies have indicated their intention of building experimental machines this year employing the principles of the castor combine.

Defoliating Castor Beans to Condition for Harvesting. Chemical spray material is required to condition plants and dry the seed capsules when harvesting before killing frosts. Past grower experience has shown that the effectiveness of defoliation with chemicals may vary for different times of the season and between seasons. Defoliation applications tested in cooperation with CRD at Davis, California, the previous year were not as effective during the current seasons. Either a second application or a greater concentration of defoliating chemicals was required for effective results.

Effect of Screw Conveyor Entrance Section Design on Castor Seed Breakage and Capacity. The fragile oil-bearing seeds are easily damaged. Broken fragments tend to cause build-up which interferes with conveying. Seed damage results in oil loss, discoloration, and reduced quality. Basic relations of the effect of entrance section design, screw speed, and entrance opening height on castor seed damage and conveyor capacity were established and expressed in the form of polynomial equations. This information may be used in the design of screw conveyors to reduce castor seed damage.

Effectiveness of Two-Drum Hullers in Hulling Castor Beans. Two-drum hullers used on castor harvesters tend to leave more capsules unhulled than other types of hullers but have the advantage of operating without requiring pre-cleaning to remove sticks and trash. Further analyses by multiple regression were made of previous data to evaluate the effect of hulling rate, clearance, and drum speed on drum huller performance. Polynomial equations with high correlation coefficient were established.

4. Development of Tung Harvester. Practically all of the tung crop is harvested with hand labor. This represents the major cost of tung production. One of the biggest problems in developing a tung harvester for effective operation is the wide range of harvesting conditions (from extremely dry and dusty to very wet) that often exists in any one harvest season. Factors affecting the cleaning ability of a perforated drum type cleaner, such as speed, angle, and air requirements were studied. The information gathered will be used to further improve the machine efficiency and performance mainly in gathering and cleaning mechanisms.

Self-propelled Tung Windrower. The rake type reel previously developed for mounting onto a tractor was incorporated in a self-propelled windrower. This machine was entirely satisfactory in windrowing on properly prepared land when the leaves and tung were either wet or dry.

5. Hauling and Handling Harvested Tung Fruit. The study on development of a bulk handling system of using pallet boxes for moving tung fruit from harvester to fieldside truck or farm storage was found to be effective for the second year. A low cost portable platform developed this year provided convenience of loading adjoining the field harvesting areas to save travel time. A pallet box with expanded metal sides and wooden bottom was lighter in weight and proved to be more sturdy than previous models.

C. Crop Preparation and Farm Processing

1. Conditioning Tung Fruit for Storage: Conditioning high moisture tung fruit for safe storage by economical means can best be accomplished when basic factors affecting release of moisture from tung fruit is understood. Investigations were initiated to determine the rate of heat penetration of tung hulls and kernels having different moisture contents. Data obtained previously on drying characteristics were analyzed in forms of graphs to show the relation in rate of moisture removal and static pressures for different depths of tung to several air flow rates. This information is to be used as a guide for further studies to cover a wider range of drying conditions.

2. Tung Hullers: Hauling requirements from farm to mill could be reduced up to 50 percent by removal of hulls. This can be accomplished only when hullers are developed which will not damage the fruit to cause oil quality deterioration. Tests on an experimental field huller showed the machine to have a capacity of 2.2 tons per hour when hulling wet fruit of 38 percent moisture (wet basis). The average kernel loss was .59 percent and the kernel to shell (covering of the kernel) was 77 percent. The machine performed better on high moisture fruit than dry.

3. Resistance of Hulled and Unhulled Castor Beans to Air Flow: At times, castor seed during harvest contain moisture in excess of the amount acceptable to processors. Such material may deteriorate in storage unless the excess moisture has been removed. Initial investigations using a pilot dryer showed the resistance to air flow in loosely filled bins for hulled seed is at least twice the resistance for unhulled castor beans with the same quantity of air flow. Exponential equations with high correlation coefficients were developed to express the relationship. Further studies are planned to obtain the effect of moisture content of castor material on resistance to air flow; also drying requirements to condition castor beans. A study is planned to determine the effect of heat, moisture, and storage on quality maintenance of castor beans.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Weed Control in Corn and Soybeans

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Oilseeds and Peanut Harvesting Equipment

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II. NUTRITION, CONSUMER, AND INDUSTRIAL USE RESEARCH

FLAXSEED

INDUSTRIAL UTILIZATION OF LINSEED OIL

Northern Utilization Research and Development Div., ARS

Problem. Traditional markets for linseed oil, the major drying oil produced and used in the United States, are threatened by widespread use of synthetic products derived from nonagricultural sources. Thus, over the years 1950-1960, use of linseed oil in drying oil products decreased from 590 to 351 million pounds because of displacement by synthetic materials capable of better performance. During the same period, consumption of synthetic products in protective coatings increased by 50 percent.

To restore the competitive position of linseed oil, new or expanded markets are urgently needed. Such markets can be achieved by an adequate program of basic and applied research. Recent studies by Department scientists have resulted in commercial manufacture and sale of linseed emulsion paints for exterior use that are competitive with synthetic resin emulsion paints. Use of these new linseed oil paints is expected to expand and assist in maintaining linseed oil in the market for exterior paints, which amounted to 70-75 million gallons in 1962. Another new product from linseed oil to which Department research is contributing is a protective coating for concrete that prevents deterioration from deicers and freezing and thawing in winter. Indications are that use of these two new products may halt the decline in consumption of linseed oil. However, additional research is needed to insure maximum acceptance and consumption of these new coatings and to provide still other new or improved products from linseed oil that can maintain and increase its use in all types of protective coatings, a market exceeding 640 million gallons in 1962.

Other new outlets can be realized by chemical modification of linseed oil to obtain materials that will find applications in the multibillion-pound annual market for products of the organic chemical industry. To furnish a sound basis for chemical modification, a broad program of basic research on linseed oil is required to furnish new leads and new concepts that will point the way to those products having the best chance for acceptance.

USDA PROGRAM

The Department conducts a continuing long-range program involving analytical, organic and physical chemists and chemical engineers engaged in basic research and on the chemical reactions of linseed oil and its component fatty acids and in the application of the knowledge gained to the development of new or improved products for the chemical and protective coating industries.

The Federal scientific effort concerned with research on industrial uses for linseed oil totals 21.8 professional man-years. Of this number 6.0 is devoted to industrial chemical products and 15.8 to protective coating products.

The current program at Peoria, Illinois, does not include research specifically devoted to chemical composition and physical properties.

Research at Peoria, Illinois, on industrial chemical products (6.0 professional man-years) involves exploratory studies to find new reactions and chemical derivatives and basic and applied research on cyclic fatty acids. During the reporting period contract research to identify promising applications for aldehyde products from linseed oil was completed.

Studies on protective coating products in progress at Peoria, Illinois, (14.4 professional man-years) include investigations on new polymers from linseed oil for use as water-soluble vehicles for coatings and basic and applied research on problems related to development of linseed emulsion paints. During the reporting period research was discontinued on linseed vinyl ethers and their use as protective coatings, except for provision of samples to interested industrial companies. Research contracts on protective coating products (1.4 professional man-years) are in effect with the University of Southern California, Los Angeles, California, for basic physical chemical studies on linseed oil emulsions and pigment suspensions (.7 professional man-year) and with Kansas State University, Manhattan, Kansas, for research on the use of linseed oil to protect concrete (.7 professional man-year).

The Department also sponsors research conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves a grant to the Experiment Station for Fats and Oils, Milan, Italy, for studies on minor constituents of linseed oil (5 years, 1960-1965). Research on industrial chemical products is conducted by this institution also under a grant for the investigation of products obtained by thermal polymerization of linseed and other polyunsaturated vegetable oils (4 years, 1960-1964) and by the Regional Research Laboratory, Hyderabad, India, under a grant for exploratory studies on hydroxylation of linseed and safflower oils (5 years, 1963-1968). Research on protective coating products involves a grant to the Paint Research Station, Teddington, England, for fundamental research on organometallic compounds as components of protective coatings (5 years, 1960-1965).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE RESEARCH

A. Chemical Composition and Physical Properties

1. Minor constituents of linseed oil. Progress continues to be made on the isolation and identification of the components of the unsaponifiables of linseed oil. Although the substance responsible for the positive Fitelson reaction in tea seed oil has been tentatively identified as butyrospermol and several substances of similar structure have been shown to give a positive test, the identity of the Fitelson positive component or components in linseed unsaponifiables is still uncertain. Linseed sterols were found to comprise β-sitosterol, stigmasterol and an unidentified

sterol. Chromatography of unsaponifiables from six different samples of U. S. linseed oil revealed qualitative differences in composition. The work thus far has yielded information on the nature of the linseed unsaponifiables that should be useful in increasing the utilization of linseed oil in industrial products. This research is being performed by the Experiment Station for the Fats and Oils Industry, Milan, Italy, under a PL 480 grant.

B. Industrial Chemical Products

1. Cyclic acids. It has been discovered that when C_{18} cyclized monomer is improperly hydrogenated over a palladium catalyst, both saturated (cyclohexane type) and aromatic cyclic acids are produced in varying proportions depending on conditions. Detailed studies revealed reaction conditions that permit high conversions of cyclic acids either to pure aromatized acids or to hydrogenated cyclic acids free of aromatic product. Addition of a substituted ethylene to a conjugated dienoic acid was found to be much more difficult than that of ethylene itself. Thus with 9,11-t,t-octadecadienoic acid, ethylene gave a 92-percent yield of product at 260°, whereas isobutylene gave no adduct at 260° but did give a 35-percent yield at 295°. (C_{18} materials result from alkaline cyclization; C_{20} materials from ethylene addition.)

Liquid-liquid extraction tests on monomeric fatty acids from the alkaline cyclization of linseed oil showed that cyclic acid content could be increased from 45 percent in the feed to 80 percent in the extract. However, to displace the more costly low-temperature crystallization method, purity approaching 100 percent must be achieved. Other studies showed that 99-percent recovery of ethylene glycol, the solvent for cyclization, could be attained. The "cost-to-make" for hydrogenated cyclic acid has been reestimated on the basis of present knowledge to be 40 cents per pound for a plant producing 4 million pounds per year. The "cost-to-make" for crude cyclic acid mixture (contains cyclic acid, unreacted fatty acids and some polymer) is estimated at 20 cents and for polymer-free mixture, 22.5 cents.

Fatty alcohols have been prepared from several types of cyclic acid products. Evaluations by an industrial company indicate promise for certain of these alcohols as components of cosmetics. Vinyl esters of hydrogenated C_{18} cyclic acids were obtained by direct vinylation in yields of over 90 percent of once-distilled product.

2. Glyceride polymers. In research under a PL 480 grant at the Experiment Station for the Fats and Oils Industry, Milan, Italy, valuable information has been obtained on polymerized linseed oil by studying the structure of the glycerides and the acids obtained therefrom. Evaluation of the data collected thus far has enabled the investigators to deduce some of the reactions involved in heat polymerization of linseed oil. For example, the initial step appears to be dimerization of the glyceride. Two dimers then

react to form tetramers which undergo further polymerization reactions. This information may be useful in preparing better commercial products of this type, thus increasing the utilization of linseed oil.

C. Protective Coating Products

1. Emulsion paints. Studies have shown that a change of 0.1 HLB unit (HLB is a numerical measure of the tendency of surfactants to produce oil-in-water emulsions as compared to water-in-oil emulsions) may be sufficient to decrease the stability of ZnO-containing emulsion paints. Reactivity of ZnO was decreased by treating it with ethylene glycol before adding other ingredients of the pigment dispersion. Extensive studies of adsorption of phosphates on zinc and titanium oxides have led to a correlation between monolayer adsorption and minimum requirement for viscosity stability. A new technique which uses inversion with slow-speed stirring gave dispersions of small particle size (ca. 1 micron) from high-viscosity, bodied linseed oils. Based on these studies, a series of emulsion paints designed to compare linseed oils having different degrees of polymerization and to investigate the effect of inorganic phosphate dispersant on mildewcidal properties of zinc oxide has been prepared. Three member companies of the NFPA will conduct and evaluate outdoor exposure tests and tests of application properties of these paints.

At the University of Southern California experimental phases of contract research on emulsion paints have been completed. In the concluding work a method was developed for determining the total interfacial area of oil-in-water emulsions. Stability was shown to be greater for emulsions with larger interfacial areas and for those having the larger fraction of the interfacial area covered with stabilizer (sodium dodecyl sulfate). Further application of the ultracentrifugal method for quantitative measurement of emulsion stability involved study of several variables important to practical paint systems. For example, it was shown that increasing the volume fraction of oil in an emulsion increased stability. Studies on drop-size distribution of M-37 linseed oil emulsions showed that smaller drops were formed in the presence of small percentages of ZnO and stability of the emulsions decreased.

Research on linseed emulsion paints continues to provide information important to the continued development of these paints on a commercial basis. Three companies now make linseed emulsions available to paint manufacturers. A fourth company is marketing a 100-percent solids product for dispersal in water by the user, and a fifth is marketing a water-soluble vehicle based on linseed oil. A recent report indicates that consumption of water-based exterior paints shows a growth rate approaching three times that of the paint industry as a whole. The increasing number of companies marketing linseed emulsion paints indicates growing consumer acceptance and suggests that a large share of the expanding market for water-based exterior coatings will be captured by linseed emulsion paints. The basic aspects of our research on linseed emulsion paints are especially important because

they will provide the key to solution of problems that will inevitably arise. For example, one manufacturer of linseed emulsion vehicles has credited the Northern Division research on pigment interaction with solution of a problem encountered in pigmenting the emulsion. Furthermore, the basic research on emulsion paints as well as that on water-soluble vehicles and on new polymers for coatings will provide the foundation for improved products to meet future competition.

2. Linseed coatings for concrete. At Kansas State University preparation of suitable concrete slabs, as specified in the contract, has been completed and the freeze-thaw phase of work has begun. A stable 50-percent emulsion of boiled linseed oil was developed at the Northern Division for use in this research in addition to solutions of linseed oil in mineral spirits. The objective of this work is to obtain precise information on the value of linseed oil in protecting air-entrained concrete from deterioration caused by freezing and thawing with application of deicers in winter. A growing number of states are using linseed oil in quantity for coating highways or are experimenting with it. Preliminary laboratory and field results indicate that emulsified boiled linseed oil can be used as a curing compound for concrete. On the basis of 1962 highway construction, the potential market for linseed oil on highways is 50 million pounds per year. Use on other concrete structures such as dams, buildings, etc., could increase this potential market considerably.

3. Water-soluble and other new vehicles based on linseed oil. Good progress is being made in the initial phases of recently undertaken research designed to develop new water-soluble and other improved vehicles and coatings resins from linseed oil. A vehicle that is soluble in aqueous isopropanol, sets to touch in 4 hours and dries hard and tack-free in 16 hours was prepared from tris(hydroxymethyl)aminomethane, itaconic acid, linseed fatty acids and dimethylaminoethanol. Attempts to prepare dilinseed esters of α-methyl or α-allyl glucoside by direct esterification or by alcoholysis of linseed methyl esters gave a mixture of products. These have been tentatively identified as the tetramethyl ester, several triesters, including the 2,4,6-triester, the 2,3-diester and the 3- and 6-monoesters.

Procedures have been developed for preparation in high yields and purity of the monolinseed ester of ethylene glycol and the hydroxyethyl amide of linseed fatty acids. These products are intermediates for study in preparation of new types of vinyl monomers.

4. Organometallic compounds in paints. A series of novel organometallic derivatives has been prepared by reaction of long-chain unsaturated acetoacetates with aluminum or titanium alkoxides. Several of the products showed promising properties as coatings. Compatible mixtures with alkyd resins were prepared that behaved well with respect to accelerated weathering and water-resistance and that showed improved adhesion to mild steel in comparison to the original alkyd. Derivatives of gallates formed from

castor oil and a castor oil modified alkyd showed promise as primers for mild steel. Studies on interactions of pigments and coating media indicated that titanium dioxide adsorbs a fatty acid in part, and perhaps wholly, by an ionic mechanism. This work is being performed by the Paint Research Station, Teddington, England, under a PL 480 grant.

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SOYBEANS
FOOD AND INDUSTRIAL USES FOR SOYBEAN OIL
Northern Utilization Research and Development Div., ARS

Problem. Soybean oil is now the major edible oil of the United States and the most important source of nutritionally important linoleic acid. However, this oil contains an unstable component (linolenic acid) that limits its use as a liquid oil both domestically and in foreign markets. It is estimated that in 1962 at least 3.4 billion pounds of soybean oil (about 90 percent of total domestic use) was consumed in edible products, of which somewhat more than two-thirds was consumed in hydrogenated form as margarine and shortening. However, production of soybeans continues to increase rapidly and exceeded 670 million bushels in 1962.

The most promising outlets for oil from this ever-growing production of soybeans appear to be in foreign markets as edible oils and fats and in domestic industrial uses. The potential market for vegetable oils imported by Europe is estimated at 7.5 billion pounds by 1975. For soybean oil to capture a growing share of this market, more information is needed to show how to eliminate unstable linolenic acid without loss of nutritive value, to determine the extent to which minor constituents influence flavor and other properties of the oil, and to discover methods for modifying hydrogenated soybean oil to achieve desired functional properties such as melting point and texture. This information would also serve as the basis for improving soybean oil for domestic use both as a liquid oil and in its hydrogenated forms. Some additional consumption in the United States might be anticipated because of extended utility resulting from these improvements, even though consumption of edible fats and oils mainly increases with population growth. To achieve the objective, a broad program of basic and applied research is required to provide more knowledge of the properties of linolenic acid and of minor constituents of soybean oil; of the changes that take place in these and other components during oxidation, hydrogenation, and heating; of the effects of these changes on flavor, nutritive value, stability, and other qualities of the oil; and of the effects of modification of glyceride structure on functional properties of hydrogenated forms of soybean oil.

As an industrial oil, soybean, like linseed oil, is faced with growing competition from synthetic products derived from nonagricultural sources. As an industrial source of linoleic acid, soybean fatty acids must also compete with tall oil fatty acids, a byproduct of paper manufacture. The best opportunity for increasing industrial applications of soybean oil appears, therefore, to be development of products that retain the glyceride structure of the oil. Thus, aldehyde oils, a recent discovery of Department scientists, appear to have a promising future, if current research and development is successful, in the 3-billion-pound market for resins, fibers, coatings, plastics, plasticizers, pesticides, and paper and textile chemicals. To achieve the potential industrial value of aldehyde oils and other

soybean glyceride products, more fundamental information is needed on reactions of soybean oil that will preserve the glyceride structure and on the physical and chemical properties of the products. Upon this basis, development of a wide variety of new, industrially useful products should be possible.

USDA PROGRAM

The Department has a continuing long-range program involving analytical, organic and physical chemists and chemical engineers engaged in basic and applied research on edible and industrial uses of soybean oil. A food technologist is also required by the program in connection with organoleptic evaluation of edible oils. Objectives of research on edible soybean oil are to identify undesirable flavor components of the oil, to develop basic information on the chemical changes and mechanisms involved in formation or suppression of these components and to apply the knowledge gained to the development of edible soybean oil having improved oxidative, thermal and organoleptic stability. Objectives of research on industrial utilization are to obtain new information on reactions of soybean oil and its components and to use this information to develop new or improved products for use by the chemical and other industries.

The Federal scientific effort for research on soybean oil totals 31.4 professional man-years. Of this number 9.0 are devoted to chemical composition and physical properties, 11.4 to edible utilization, and 11.0 to industrial utilization.

Research at Peoria, Illinois, on chemical composition and physical properties (9.0 professional man-years) is concerned with isolation and identification of components affecting flavor stability of soybean oil. During the reporting period basic studies on autoxidation of soybean oil were completed.

Research at Peoria, Illinois, on edible utilization of soybean oil (8.5 professional man-years) involves basic and applied studies on selective hydrogenation and on interesterification followed by selective extraction as means of stabilizing soybean oil by removal of linolenate. Studies are also in progress on the stability of mixtures of soybean oil with other edible oils. Research contracts (2.9 professional man-years) are in effect at Armour Research Foundation, Chicago, Illinois, for development of heterogeneous selective hydrogenation catalysts (1.4 professional man-years); at Rutgers, The State University, New Brunswick, New Jersey, for basic studies on heterogeneous catalysts (1.0 professional man-year); and at the University of Illinois, Urbana, Illinois, for basic research on homogeneous catalysts (.5 professional man-year). During the reporting period a contract project was completed that covered preparation and evaluation of several types of heterogeneous catalysts.

Research at Peoria, Illinois, on industrial utilization of soybean oil (10.6 professional man-years) involves exploratory studies to find new reactions and products and basic and applied investigations of aldehyde oils and other aldehydic products. A research contract (.4 professional man-year) is in effect with North Dakota State University of Agriculture and Applied Science for investigations of aldehyde oils as components of protective coatings. During the reporting period contract research to identify promising applications for aldehyde products from soybean oil was completed.

The Department also sponsors research on soybean oil conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to the Institute for Fats and Their Derivatives, Seville, Spain, for research on removal of trace metals from soybean oil with ion-exchange resins (5 years, 1960-1965) and to Gdansk Polytechnic, Gdansk, Poland, for studies on soybean sterols and their effect on stability of the oil (4 years, 1961-1965). Research on edible utilization is conducted under grants to the University of Granada, Spain, for studies on the effect of processing on frying quality of soybean oil (5 years, 1962-1967) and to Tokyo University, Japan, for research on hydrogenation of soybean oil (3 years, 1962-1965). Research on industrial utilization involves grants to the University of Helsinki, Finland, for studies on separation of pure fatty acids from mixtures such as soybean fatty acids (5 years, 1960-1965); Queen Mary College, University of London, England, for basic studies on alkaline cleavage of polyunsaturated fatty acids (4 years, 1960-1964); and the Experiment Station for the Fats and Oils Industry, Milan, Italy, for research on oxidation with atmospheric oxygen to obtain new soybean oil derivatives (4 years, 1960-1964).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Flavor components. The hydrocarbon portion, which comprises 10 to 15 percent of the unsaponifiables of soybean oil, was shown to be primarily responsible for flavor deterioration caused by unsaponifiables. Squalene constituted 50 percent of the mixture and contained most of the unsaturation. Some unsaturation was observed in two compounds of C_{23} and C_{26} carbon chain length. A crystalline portion, constituting 4.2 percent of the hydrocarbons, was composed primarily of C_{29} and C_{31} saturated hydrocarbons, with some C_{27} and C_{30} being present. The remainder was a very complex mixture of C_{15} to C_{35} hydrocarbons. About 1 percent of unsaponifiables is present in soybean oil.

New analytical techniques, which involve a combination of hydrolysis with lipase and chromatographic analysis of the monoglycerides so produced, were developed and used to demonstrate and confirm the postulated intramolecular random arrangement of unsaturated fatty acid groups in soybean and other oils.

2. Removal of prooxidant metals. In studies under a PL 480 grant at the Institute for Fats and Their Derivatives, Seville, Spain, efficient removal of prooxidant metals from soybean oil has been achieved by use of ion-exchange resins. Organoleptic tests showed that this removal resulted in improvement in flavor stability statistically significant at the 5- and 1-percent levels.

3. Effects of sterols on flavor stability. Experiments at Gdansk Polytechnic, Gdansk, Poland, showed that chemical changes in soybean sterols result from the action of bleaching earths. Soybean sterols and their alteration products are being characterized by chromatographic and spectrophotometric techniques. Results suggest that steroid compounds with increased unsaturation caused by dehydration are formed. This research is being conducted under a PL 480 grant.

B. Edible Utilization

1. Selective hydrogenation. In basic studies on kinetics and mechanism of hydrogenation, several important advances were made: (1) anticipated isotopic effects were not observed in catalytic reduction of methyl oleate with hydrogen-deuterium-tritium gas mixtures; (2) extensive exchange of deuterium for carbon-bonded hydrogen was shown to occur during catalytic reduction of methyl oleate with deuterium; (3) in analogous reductions of methyl 9,10-ditritiooctadec-9-enoate, tritium was not released during saturation of the double bond but appears upon completion of the reduction; (4) homogeneous catalytic hydrogenation of sodium sorbate with pentacyanocobaltate II as catalyst gave 80-, 19- and 1-percent yields of 2-, 3- and 4-hexenoic acids; (5) a small analog computer was assembled and applied successfully to kinetic problems of selective hydrogenation.

Iron pentacarbonyl was found to be an effective homogeneous catalyst for hydrogenation of soybean oil and its methyl esters. However, there was no selectivity towards linolenate, and isomerization occurred with accumulation of trans-containing dienes (conjugated) and monoenes. There was little or no increase in saturates. In heterogeneous hydrogenation of methyl linolenate, platinum was less selective than commercial nickel catalyst, but there was less bond migration and trans formation. A rapid quantitative method was developed for use of nuclear magnetic resonance in determining the 15,16 double bond content of lipids.

Studies of the hydrogenation-winterization process showed that changes in fatty acid composition, trans-acid formation, and yield of winterized oil were approximately linear with degree of hydrogenation.

In final phases of contract research at Armour Research Foundation, catalysts consisting of nickel supported on molecular sieves showed selectivities for linolenic over linoleic as high as 2.9, but selectivities at least as high as 8 may be needed for commercial use. Trans isomers were in the range of 4 to 13.8 percent, and better results were obtained at

65-80° C. than at 100-150°, the temperature used with conventional supported nickel catalysts.

2. Improving flavor stability. Flavor scores of soybean, cottonseed and partially hydrogenated soybean oils exposed to fluorescent light for periods of 1 to 4 hours have been found to correlate well with those for oils submitted to oven storage (4 days required) and the A.O.M. test (8 hours required). Safflower oil, even though it is highly unsaturated and does not have high heat stability, showed surprising stability to fluorescent light. Heating of degassed oils under vacuum was found to be very deleterious to flavor. When oils of differing stability were mixed, the stability of the mixture was observed to vary linearly with composition.

The rapidity and convenience of testing by exposure to fluorescent light will expedite studies planned on flavor stability. Furthermore, this type of test, by providing information on factors contributing to light instability, can contribute to solution of problems arising from packaging of oils in clear glass bottles. Observation of the unusual light stability of safflower oil is very significant, since it has commonly been believed that stability of oils became greater as their iodine number decreased. It is now evident that other factors are operative. Elucidation of these factors should make possible further important advances in stabilizing liquid soybean oil.

3. Frying quality of soybean oil. Preliminary taste panel tests have shown that when potatoes are fried in soybean oil, olive oil, or a 50-50 mixture of soybean and olive oil, it is impossible to distinguish the type of oil used. Since these results were based on oil used for one frying operation only, it has been suggested that further studies be made on continued or repeated use of the oil in deep-fat frying. This research is being conducted by the University of Granada, Granada, Spain, under a PL 480 grant.

4. Partial hydrogenation of soybean oil. Initial experiments under a PL 480 grant at Toyo University, Kawagoe, Saitama-ken, Japan, showed that Cu-Cr-catalyst and Cu-Cr-Mn-catalyst were effective for "selective" hydrogenation of soybean oil at comparatively low temperatures and small amounts of catalysts. The meaning of "selective" hydrogenation was not given but it is presumed to mean hydrogenation to monoenes. Cu-Ni-catalysts were ineffective but their preparation will be studied further.

C. Industrial Utilization

1. Oxidative cleavage of soybean oil and its fatty acids. By use of the bisulfite adduct, methyl azelaaldehydate of 99.8-percent purity can be obtained. Experiments on partial ozonization of methyl linoleate and linolenate indicated that attack by ozone was essentially random. The C-12 and C-15 aldehyde esters thus prepared are being characterized.

Procedures have been developed for isolation in 70-percent yields of malonaldehyde (as its tetramethyl acetal) from the ozonization products of polyunsaturated systems. In engineering studies, treatment of aldehyde products with cation exchange resins was found to improve color substantially and to minimize undesired polymerization. The resin, which presumably removes metallic contaminants, can be regenerated and reused.

2. Aldehyde oils and derivatives. Linear elastomeric poly(ester-acetals) have been prepared from methyl azelaaldehydate (MAZ) and glycerol. Another new polymer was obtained by simultaneous hydrolysis and polymerization of isopropylidineglyceryl azelaaldehydate dimethyl acetal under conditions similar to those for interfacial polymerization. Studies point to boron trifluoride as the best catalyst for crosslinking poly(ester-acetal) resins on glass. Coatings required baking at 300° C. to achieve adherent, solvent-resistant films. Five additional ester-acetal derivatives of azelaaldehydic acid were prepared for evaluation at the Eastern Utilization Research and Development Division as plasticizers and stabilizers for vinyl plastics. Vinylation of the methanol and ethylene glycol acetals of azelaaldehydic acid gave the corresponding vinyl esters in about 90-percent yields. These products will be evaluated as internal plasticizers for poly(vinyl chloride).

Contract studies at Battelle have been completed. Acetals of aldehyde oils and of MAZ were shown to react more readily with polyols than did the free aldehyde forms. The reaction product of trialdehyde oil acetal with methyl glucoside was a thermoplastic solid that shows promise as a hot-melt adhesive for nonpolar polymers such as polyethylene. The reaction product from MAZ and dextrose gave a hard film on glass that was insensitive to boiling water. A tough, elastomeric product possibly useful as a plasticizing agent was obtained from poly(vinyl alcohol) and MAZ acetal.

Industrial interest in aldehyde oils and related materials continues to grow. Recently a semicommercial quantity of MAZ was produced by an industrial company at the request of a leading manufacturer of resins and plasticizers. A third company is considering pilot-plant production. Prospects appear good for ultimate commercialization of MAZ. However, progress in finding promising uses for aldehyde oils has been slow. Because of the unusual chemical nature of aldehyde oils, basic studies should be emphasized in order to develop new information on their properties and reactions that can assist in finding industrial outlets for these products.

3. Separation of fatty acids. Research under a PL 480 grant at the University of Helsinki, Finland, has shown that crystallization of soybean oil and linseed oil fatty acid-fatty acid soap mixtures from methanol solution at low temperatures yields fractions containing over 90 percent of polyunsaturated fatty acids. Solvent requirements were not excessive, but recoveries of polyunsaturated acids were low. Separation of linoleic acid from linolenic acid, contained in concentrates, was not feasible at practical temperatures.

4. New derivatives. Alkali fusion of hydroxyketo fatty acids where the hydroxy- and keto-groups are adjacent and removed from the carboxylic acid group gave excellent yields of dibasic acids by cleavage between the keto- and hydroxy-groups. Studies supported the hypothesis that alkali fusion of unsaturated fatty acids proceeds through movement of the double bond to the alpha or two position in the chain. These studies are in progress under a PL 480 grant to Queen Mary College, University of London, England.

Under a PL 480 grant to the Experiment Station for the Fats and Oils Industry, Milan, Italy, metal chelates of Cu^{II}, Co^{II}, Ni^{II}, Fe^{II}, Fe^{III}, and Zn^{II} with Schiff bases derived from salicyl aldehyde and long-chain substituted diamines have been prepared and purified. Methyl oleate and linseed methyl esters have been oxidized with these chelates and with those from the Schiff base of ethylene diamine and salicyl aldehyde ("Calvin chelates"). Initial studies on the separation and identification of methyl oleate oxidation products have been carried out.

PUBLICATIONS AND PATENTS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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SOYBEANS
FEED, FOOD AND INDUSTRIAL USES FOR MEAL AND PROTEIN
Northern Utilization Research and Development Div., ARS

Problem. Production of soybeans continues to increase rapidly and exceeded 670 million bushels in 1962. For profitable disposition, now and in the future, of the growing supplies of meal from U. S. soybeans, improved feed products and new food and industrial uses are needed. Europe is developing a mixed-feed industry that needs high-protein concentrates. This market could approach that in the U. S. which uses high-protein meal from 450 million bushels of soybeans. For U. S. soybeans to achieve the maximum share of this market, more fundamental information is needed on the proteins and other nutritionally important constituents of soybeans and on the effects of processing on these components. Such information should make possible the production of feeds from soybeans having maximum feeding value that would meet the requirements of foreign markets as well as help maintain or increase the use of soybean feeds in the U. S.

U. S. soybeans could play a dominant role in alleviating the world shortage of dietary protein if more information were available on utilizing soybeans and soybean meal, flour, protein and protein concentrates in food products tailored to meet the nutritional and palatability requirements of foreign markets. That the possibilities are very real for increased utilization of soybeans in foreign foods is indicated by recent work of the Department that showed how to use U. S. soybeans for Japanese foods. The result of this work was that a market for selected soybeans for Japan was opened that now exceeds one million bushels per year. If U. S. soybeans are to achieve the maximum share of foreign food markets, basic information on nutritionally important components and effects of processing on these components will be needed. In addition, better knowledge will be required of how to use soybean protein products in foodstuffs that will be acceptable abroad.

Opportunities also exist for developing new or improved products from soybean meal and protein for industrial use in adhesives, surfactants, emulsifiers, viscosity improvers, and related products. For example, a successful method for stabilizing soybean protein against microbial attack could result in regaining the market for soybean protein as viscosity improvers for water-base paints or as emulsifiers for asphalt. This potential could be realized if more basic information were available on the physical and chemical properties and chemical reactions of components of soybean meal.

USDA PROGRAM

The Department has a continuing long-range program involving organic and physical chemists and biochemists engaged in basic research on the characterization of components of soybean meal and protein and application of

the knowledge gained to solution of problems encountered in processing and utilization of soybean meal and protein.

The Federal scientific effort on utilization of soybeans and soybean meal and protein totals 11.2 professional man-years. Of this number 4.2 are devoted to chemical composition and physical properties and 7.0 to food products.

Research at Peoria, Illinois, on chemical composition and physical properties (4.2 professional man-years) involves basic studies on isolation and characterization of components of whey proteins and acid-precipitated proteins.

Research at Peoria, Illinois, on food products (6.6 professional man-years) is devoted to development of information on specially processed soybean products pertinent to their use in high-protein foods for foreign markets. A research contract (.4 professional man-year) at the University of Illinois, Urbana, Illinois, is concerned with investigation of factors possibly present in soybeans that could cause digestive disturbances.

The current program at Peoria, Illinois, does not include research on industrial or feed products. During the reporting period the project covering research on stabilization of soybean protein against microbial attack, which had been in abeyance, was discontinued.

The Department also sponsors research on utilization of soybeans conducted by foreign institutions under grants of PL 480 funds. Research on chemical composition and physical properties involves grants to the University of Edinburgh, Scotland, for investigations on polysaccharides of soybeans (4 years, 1960-1964); to the Weizmann Institute of Science, Rehovot, Israel, for research on complexes between soybean protein and other components of the meal (5 years, 1961-1966); and to Kagawa University, Kagawa, Japan, for a chromatographic study of soybean sugars and oligosaccharides (3 years, 1963-1966).

Research on food products involves grants to the National Institute of Nutrition, Rome, Italy, for studies on use of soybean protein in pasta (4 years, 1960-1964); the Central Miso Institute, Tokyo, Japan, for studies on miso made from dehulled soybean grits (3 years, 1962-1965); Bar-Ilan University, Ramat Gan, Israel, for studies on miso-type food products for use in Israel (3 years, 1962-1965); Israel Institute of Technology, Haifa, Israel, for evaluation of the quality of isolated soybean protein for use in Israeli foods (4 years, 1962-1966); Japan Tofu Association, Tokyo, Japan, for studies on the use of U. S. soybeans for making tofu (2 years, 1963-1965); Academica Sinica, Nankong, Taiwan, for investigation on preparing Chinese cheese from soybeans (5 years, 1963-1968); and Noda Institute for Scientific Research, Noda-chi, Chiba-ken, Japan, for studies on improved strains of Saccharomyces rouxii for making shoyu and miso (5 years, 1963-1968). Also, a contract, financed with PL 480 funds, has been placed with

the Japan Shoyu Institute, Tokyo, Japan, for comparative evaluations of soy sauces prepared from Japanese and U. S. soybeans (2.5 years, 1961-1963).

Research on feed products involves a grant to the Hebrew University, Rehovot, Israel, for basic studies on soybean saponins (5 years, 1961-1966).

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Acid-precipitated protein. Fractionation of material extracted by 86-percent ethanol from dialyzed, acid-precipitated protein indicated presence of over 25 components. Those identified so far are triglyceride, which comprises about one-third of the material, and smaller amounts of phosphatidyl choline, phosphatidyl ethanol amine and genistein. Studies on denaturation of isolated protein with isopropanol showed that 40 percent isopropanol was most effective. Rate of denaturation increased with temperature but was unaffected by pH over the range 4.5 to 7.5. Both the 11S and 7S components were insolubilized by isopropanol; the 7S component was more sensitive to denaturation than the 11S. Other studies of 11S component of soybean protein showed that the apparent molecular weight decreases with increasing protein concentration.

2. Whey proteins. Soybean trypsin inhibitors A_1 and A_2 caused growth inhibition and pancreatic hypertrophy. These results are similar to those obtained earlier with purified Kunitz inhibitor. Rat bioassays showed that in a 10-percent-casein diet 0.5 percent of crystalline trypsin inhibitor caused nearly maximum growth inhibition and pancreatic hypertrophy, whereas in a 14-percent-casein diet 0.6 percent of inhibitor had no effect on growth but did produce maximum pancreatic hypertrophy. Feeding tests were performed at the Western Division.

The indication that an increased level of protein in the diet can overcome growth inhibition by trypsin inhibitor may explain many of the contradictory observations and conclusions hitherto associated with studies of the nutritive value of raw soybean meal. New opportunities for development of improved soybean meals may result from further study of this phenomenon.

3. Soybean polysaccharides. Under a PL 480 grant to the University of Edinburgh, Scotland, two galactomannans, two pectic acids, and two hemicelluloses have been isolated from soybean hulls and their structures are being determined. Further fractionation and isolation of polysaccharides from hulls and from soybean cotyledon meal are underway. The rate of progress indicates that the major polysaccharides in soybeans will be isolated and characterized during the course of this project.

4. Complexes of soybean protein with other meal constituents. The Weizmann Institute of Science, Rehovot, Israel, has fractionated soybean proteins using DEAE-cellulose and calcium phosphate chromatographic

procedures. The protein fractions were examined for antiproteolytic, hemagglutinating, and β-amylase activities. Ultraviolet spectral studies indicated the presence of nucleic acids in two of the protein fractions. This work is being performed under a PL 480 grant.

B. Food Products

1. Tempeh. Tempeh is an Indonesian food product obtained by fermentation of soybeans with strains of Rhizopus mold, of which research at the Northern Division showed R. oligosporus to be the best producing strain.

Primitive methods used in Indonesia to make tempeh have been adapted to a rapid, simple process. In this modern process, pure strains of the tempeh-producing mold are used, and the soybeans are fermented in plastic packages. The traditional method uses mixed strains of mold for fermentation and banana leaves for packaging.

Feeding tests conducted at the Western Division suggested that tempeh made by short-term fermentation with Rhizopus may effect a slight decrease in protein efficiency with rats when compared to full-fat soybean flour. Amino acid analysis is not precise enough to show a loss of any of the essential amino acids in a 24-hour fermentation. The rat-feeding studies showed that protein efficiency ratio for tempeh varied from 2.35 to 2.64 compared to 2.62 to 2.78 for toasted full-fat soybean meal. Only the lowest value for tempeh represents a statistically significant decrease in nutritive value. Degree of fermentation may be responsible for the variable protein efficiency ratio of tempeh. Other work elsewhere with tempeh fermented for longer periods has shown that a loss of methionine does occur. Unidentified factors, perhaps vitamins or minerals, could be involved. The nutritional value of tempeh made by the Northern Division process appears, however, to be adequate to justify use of the process in any country.

Soybeans were found to contain a water-soluble and heat-stable substance that inhibits tempeh fermentation. This inhibitor causes no problem if water used in soaking, cooking and washing the soybeans is removed. These operations result, however, in losses amounting to about 25 percent of the weight of the beans. Studies are in progress to isolate and identify the inhibitor and to find means for its inactivation or elimination. An assay was developed for following activity of the soybean tempeh mold inhibitor during fractionation and isolation studies.

2. Full-fat soybean flour. UNICEF cooperative program. Three large-scale pilot runs at Wenger Mixer Manufacturing Company showed that a product having nutritional value comparable to commercially toasted soybean flakes could be obtained by the expansion cooking process and provided detailed information on a number of critical operating variables. Twelve tons of dehulled soybeans were flaked by Loma Linda Food Company and processed by Wenger in 12 separate tests. Samples from each test were converted to flour

at the Northern Division. Proximate analysis met specifications of commercial full-fat soybean flours. Rat bioassays and chick feeding tests indicated high biological value comparable to that of commercial toasted soybean meal. Preliminary tests of oxidative stability of the flour have given encouraging results. Results continue to be favorable to the future development of the expansion cooking process as a rapid, simple method for small-scale processing suitable for use overseas. Furthermore, important new information correlating processing conditions with biological value is being obtained. UNICEF plans test feeding of the full-fat soybean flours to 3,000 children in Taiwan in comparison with commercial soybean food products.

3. Flavor and nutritive qualities of soybean food products. Treatment with steam for 4 minutes was found to remove most of the raw beany flavor from soybean flakes; grits and whole beans required a slightly longer time. Prolonged treatment did not remove all flavor from full-fat flour. Use of ultrahigh frequency (UHF) radio waves on whole soybeans removed the beany flavor in 3 to 4 minutes. During the treatment the beans swelled, hulls were loosened, and the texture became friable. Residual flavor resembled that of peanuts. Urease activity was comparable to that of flakes steamed 6 to 10 minutes. Puffing beans with steam at 220 p.s.i. after 25 seconds in a puffing "gun" was sufficient to remove flavor.

4. Comparison of U. S. and Japanese soybeans for soy sauce. Ordinary U. S. and Japanese soybeans have been compared on a commercial scale in the making of soy sauce (shoyu) at 13 plants in Japan. Eleven of the 13 report that U. S. soybeans are somewhat superior to Japanese soybeans for making shoyu. They report specifically that the nitrogen utilization of U. S. beans is several percent higher than that for the Japanese beans. These results are very significant in promoting the export of soybeans to Japan. This research is being conducted by the Japan Shoyu Institute, Tokyo, Japan, under a PL 480 contract.

5. Quality of isolated protein for use in Israeli-type foods. Initial studies under a PL 480 grant at the Israel Institute of Technology, Haifa, Israel, indicate that untoasted soybean meal produced commercially in Israel has a very low nitrogen solubility index (NSI). As a result, yields of isolated protein were low. Factors responsible for the low NSI are being investigated.

6. Studies on miso. Under a PL 480 grant to the Central Miso Institute, Tokyo, Japan, 11 Japanese and U. S. varieties of soybeans have been studied in the preparation of miso. The U. S. soybeans had lower moisture, higher oil and less carbohydrate content than the Japanese beans, but the protein contents were almost identical. The U. S. and Japanese beans, after soaking and steaming, took up about the same amount of water and had the same hardness. After digestion with takadiastase, U. S. beans had slightly higher water-soluble nitrogen and amino nitrogen and less reducing sugar than Japanese soybeans.

In studies in progress under a PL 480 grant at Bar-Ilan University, Ramat Gan, Israel, miso has been prepared satisfactorily from soybeans in preliminary experiments, and work is underway on making miso from defatted soybean flakes. One difficulty encountered with this new substrate is the growth of the koji mold on the fermenting mass. The flakes also absorb much more water than the whole soybean and, consequently, the miso from flakes has a higher moisture content. However, samples below the mold growth are reported to be good miso.

C. Feed Products

1. Effects of saponin on nutritional quality of soybean feeds and foods. Preliminary data reported last year indicated that autoclaving soybean meal according to commercial practice destroyed most of the hemolytic activity of saponins in the meal. Further studies appear to refute the early results. Furthermore, autoclaved saponin extracts and saponin extracts from autoclaved meal inhibit the proteolysis of trypsin. Studies are underway to assess the importance of this finding on nutritional value of the meal. This research is being conducted by the Hebrew University, Rehovot, Israel, under a PL 480 grant.

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REPLACEMENT CROPS
UTILIZATION POTENTIAL - NORTHERN REGION
Northern Utilization Research and Development Div., ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available for their choice that would have different end-use patterns from those presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the United States; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and to select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

To achieve the objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potentials. Work of the Department has already revealed several promising sources of new potentially valuable water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy-unsaturated acids, capric acid, epoxidized acids, and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants, and on byproducts from processing, such as oilseed meals.

USDA PROGRAM

The Department conducts a long-range continuing program of research involving analytical and organic chemists and chemical engineers engaged in examination of uncultivated plants to find unusual and potentially useful components and in detailed characterization and evaluation studies of selected components that have the greatest industrial potential and that are obtainable from agronomically promising plants. Plants or seeds for this program are obtained by cooperation with Crops Research Division which procures material from domestic and foreign sources by means of

collecting trips or from experimental plantings. Materials from abroad are also made available through Crops Research Division PL 480 projects providing for collecting activities by foreign investigators. All seeds and plants are submitted to a broad chemical-screening program to identify sources of unusual and potentially useful components such as oils, fibers, gums, amino acids and proteins. Components of interest from plants rated by Crops Research Division as having a reasonable agronomic potential for the United States are characterized to obtain clues to areas of utilization of probable interest to industry. On the basis of the results, plants having the highest agronomic potential and containing components of greatest potential industrial value are selected for more intensive utilization research. This utilization research is divided among the four Utilization Research and Development Divisions.

The Federal scientific effort devoted to research on replacement crops at Peoria, Illinois, totals 23.1 professional man-years. Of this number, 14.5 are concerned with chemical composition and physical properties; 7.8 with industrial utilization of new oilseeds; and .8 with industrial utilization of new gum and fiber plants.

Research at Peoria, Illinois, on chemical composition and physical properties (14.2 professional man-years) involves conduct of the program on screening uncultivated plants for unusual and potentially useful oils, fibers, gums, amino acids and other components; organic chemical characterization of selected fractions and components, especially new oils fatty acids; and studies on properties of new plant fibers. A research contract (.3 professional man-year) is in effect with Montana State College, Bozeman, Montana, providing for screening and analysis of seed oils of Brassica (mustard) and related genera to identify species having greatest erucic acid content and agronomic potential.

Research at Peoria, Illinois, on industrial utilization of new oilseeds (7.8 professional man-years) involves studies on processing of erucic acid oilseeds to obtain oil and meal and investigations on utilization of erucic acid and its derivatives. During the reporting period, research was completed on development of a method for processing mustard seed to bland oil and to byproduct meal suitable for livestock feeding.

Research at Peoria, Illinois, on industrial utilization of new gum and fiber plants (.8 professional man-year) is concerned with development of methods for recovery of gums from plants; with evaluation of plant gums in industrial application; and with studies on pulping new fiber plants and evaluation of the pulp in paper, structural boards and related products. During the reporting period research on utilization of Crotalaria intermedia gum was completed.

The Department also sponsors research in this area conducted by a foreign institution under a grant of PL 480 funds (5 years, 1962-1967). This work, performed by the Institute of General Chemistry, Warsaw, Poland, is

concerned with determination of glyceride structure of erucic acid oils and is under the subheading chemical composition and physical properties.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Screening for new industrial oils. Since the last report, 690 additional samples of seeds were screened for new oils of potential interest. Oil from Crepis foetida, a species from Turkey, contained 60 percent of an acid previously observed in lower concentration in Helichrysum bracteatum. Alkali isomerization indicated 88 percent "apparent linolenic" acid while chromatography showed none. This discrepancy is explained by structural characteristics of the unknown acid (see item 2 below). Two Cuphea species contained 70 percent of caprylic acid and 20 percent of capric acid in contrast to C. llavea and C. ignea (85 percent capric acid) and C. carthagenensis (57 percent lauric and 18 percent capric acids). Six sunflower introductions from Russia contained more oil and protein than domestic samples but linoleic acid contents of the oils were in the same range (30-54 percent).

Special screening studies of the 7 available known Limnanthes species and 30 species related to Dimorphotheca were completed. In all of the Limnanthes oils, at least 95 percent of the acids are C-20 and C-22 acids with the C-20 acid (5-eicosenoic acid) predominating (52 to 77 percent). Dimorphecolic acid (28 to 75 percent) was found in all 6 of the Dimorphotheca and Castalis species tested and in 5 of the Osteospermum species. The remaining 19 species (Osteospermum, Calendula, Chrysanthemoides) contained 14 to 60 percent of a conjugated trienoic acid but little or no dimorphecolic acid. Oil from five samples of crambe seed grown in Nebraska contained 54 to 59 percent of erucic acid.

Contract research at Montana State College revealed that seed oil of an Iberis species was as high in erucic acid content as crambe oil; however, oil yield and crop potential are inferior to those of crambe. On the basis of compositional data obtained so far on Brassicas, erucic acid content of some lines is independent of environment and may be controlled by one gene. Addition of a second gene apparently results in a level of erucic acid that is influenced by environment.

2. Characterization of new seed oils and components. The unusual acid of Crepis mentioned in item 1 has been characterized as cis-9-octadecen-12-ynoic acid. In the presence of alkali this acid rearranges to conjugated trienoic acid. Cis-11-eicosenoic acid was shown to be present in the seed oils of Marshallia caespitosa, Alyssum maritimum and Selenia grandis to the extent of 44, 42, and 58 percent, respectively. About 16 percent of the fatty acids of Leonotis nepetifolia seed oil is an optically active unsaturated acid that may contain an allenic grouping and chain branching and that is convertible to an optically active saturated acid.

Studies on the glyceride structure of erucic acid oils have been initiated by the Institute of General Chemistry, Warsaw, Poland, under a PL 480 grant.

3. Characterization of components of crambe and other oilseed meals. Based on study of a limited number of species, an analytical method for determining total thioglucoside in seed meals has been developed. It depends upon estimation of sulfate ion formed by hydrolysis of thioglucoside with the enzyme myrosinase. Although sulfate formation was unaffected by pH over the range studied, the amount of oxazolidinethione was strongly pH dependent. Total thioglucoside in hexane-extracted meal ranged from 7.1 to 8.4 percent for 5 samples of crambe seed. A crystalline oxazolidinethione and a crystalline acetate of a thioglucoside have been isolated from crambe meal and are being characterized. From an 80 percent aqueous acetone extract of crambe meal, 1 to 2 percent of a crystalline prolamine protein has been isolated. The residue insoluble in aqueous acetone amounts to 75 percent of the starting material and contains 56 percent of protein high in lysine and methionine. The lipase enzyme system of crambe was found to be inactive at 12 to 15 percent moisture content or less at room temperature.

Continued studies on amino acid composition of seed meals (39 species of 16 plant families) revealed variability within previously demonstrated limits.

The crystalline protein isolated from crambe is the first prolamine that to our knowledge has been obtained in crystalline form. This accomplishment has considerable basic chemical importance. Successful isolation of crystalline thioglucoside derivative and oxazolidinethione from crambe will greatly assist studies of their properties and reactions and of methods for their destruction or inactivation. The advance in knowledge of myrosinase activity and the products formed, and the development of an analytical procedure for determining total thioglucosides in a seed meal, will be extremely valuable in developing and controlling improved methods for processing crambe. The analytical method is believed to be the first of its kind; it should, therefore, have value generally in the study of thioglucosides in plants.

4. Screening for new seed mucilages. Of 108 new species surveyed, six contained more than 20 percent of water-soluble mucilage. One is a legume, Astragalus hamosus, collected in Turkey and rated as having a good crop potential. Another four legumes, collected in Mexico, have fair to good crop potential. The remaining species, Sphinctospermum constrictum, another legume from Mexico, was rated excellent agronomically.

5. Screening for new pulp fiber plants. Data on screening studies of 172 not previously studied plant species, on 128 sorghum species samples and on statistical analysis of results with 11 selected monocots and

dicots is being summarized for publication. To complete the studies, percent pith is being determined for the sorghum samples. For the 114 samples so far analyzed, "apparent pith" ranged from 9 to 55 percent. In connection with the study of dicots and monocots, data to establish approximately 2,700 correlations are now being processed by Biometrical Services.

B. Industrial Utilization of New Oilseeds

1. Processing crambe seed. A dehulling process for crambe has been developed that increases protein content of the meal from 40 to 50 percent (moisture-free basis). Application of the enzymatic hydrolysis process to crambe yielded meal containing very low levels of isothiocyanates and oxazolidinethiones. Sulfur balances indicated, however, that 92 percent of the original sulfur was still present as inorganic sulfate, thioamino acids and uncharacterized compounds. Whereas feeding raw crambe meal to rats caused death in 4 weeks, detoxification by the enzymatic hydrolysis process gave meals which, when fed at the Western Division to rats in amounts up to 30 percent of the ration, gave growth rates up to 80 to 90 percent of that of the addis control diet. Subsequent tests showed that hydrolysis may not have been complete during processing of these meals. In view of these results and those from the basic studies on components of crambe meal (see preceding item A-3), prospects appear good for eventual development of a palatable nutritious feed meal from crambe.

2. Studies on utilization of erucic acid. Oxidative stability tests showed the following induction periods: for crude and refined crambe oil, 186 and 53-115 hours; for crude and refined soybean oil, 129 and 43 hours. Directed interesterification and fractionation of crambe oil yielded a fraction containing increased amounts of erucic acid.

In ozonization of erucic acid, conversions of over 90 percent and a yield of 98 percent pure brassylic acid amounting to 70 percent of theory were obtained. Several diesters of brassylic acid, tested at the Eastern Division, showed excellent compatibility and low temperature flexibility as plasticizers for poly(vinyl chloride). A second series of 14 aliphatic diesters of brassylic acid was prepared for evaluation at the Eastern Division as vinyl plasticizers. Tests at the Western Division indicated that brassyloyl chloride was comparable to sebacoyl chloride in the WURLAN treatment of wool. Other derivatives prepared for study include divinyl brassylate, polyoxyethylene brassylate esters, and the ester of brassylic acid and crambe alcohols.

C. Industrial Utilization of New Fiber Plants

1. Kenaf for pulp and paper. By adaptation of milling and classification techniques, and by other procedural changes, improvements have been made in mechanical pulping of kenaf to achieve more closely controlled fiber size, fiber size combinations, degree of hydration and other characteristics.

Mechanical-type pulps were obtained from kenaf in yields of 85 to over 90 percent, while yields of bleached chemical pulps were about 40 to 45 percent. Newsprint-type papers prepared from blends (30:70 parts by weight) of chemical and mechanical kenaf pulps exceeded in most physical properties the average of 50 commercial newsprint papers. All properties were within the acceptable to superior range with the possible exception of brightness, which was 90 percent of the commercial average. Two kenaf mechanical pulps prepared at the Northern Division were evaluated by the Hillenbrand Industries for resin-bonded hardboard. Strength properties were comparable to those of similar hardboards made from wood fiber. One boxcar (1,000 bags) of chopped kenaf from the planting at Batesville, Indiana, has been furnished to a major papermaking company for large-scale pulping studies.

Demonstration that kenaf mechanical pulps can be used as components of good quality newsprint and resin-bonded hardboards indicates the versatility of this pulp source. It further shows good potential, justifying further studies to optimize process efficiency and product quality.

PUBLICATIONS AND PATENTS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

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Industrial Utilization of New Oilseeds

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Industrial Utilization of New Gum and Fiber Plants

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PEANUTS PROCESSING AND PRODUCTS
Southern Utilization Research and Development Div., ARS

Problem. Peanuts constitute a major cash crop in the Southern States and are in surplus. Because of the high price of peanuts in the United States, peanuts are used almost exclusively (approximately 73 percent of the crop) in foods such as peanut butter, confections, and roasted and salted nuts. New type food products and improvement in the quality and uniformity of existing products are needed to increase consumer acceptance and extend markets; the average per capita consumption has been rather stable since World War II. The increased trend toward mechanical harvesting has necessitated the use of artificial means for curing and drying peanuts, with the result that processed peanuts and peanut products do not always possess the same desirable flavor and physical properties as peanuts which have been cured slowly in the field. Information is needed as to the physical and chemical characteristics of those chemical constituents in peanuts which affect the properties of processed products as a basis for developing new or improved products and processing procedures. Fundamental studies of peanut protein and associated materials could similarly lead to the development of new concepts and new uses.

USDA PROGRAM

The Department has a continuing long-term program involving organic chemists and biochemists, engaged in basic studies on peanuts and peanut products to increase consumer acceptance and extend markets for peanuts.

Research to develop basic information on the chemical composition and properties of peanuts, its constituents, and processed peanut products is carried out at New Orleans, Louisiana. As a part of the Seed Protein Pioneering Research Laboratory's research on various seed proteins, fundamental investigations of peanut proteins and associated materials are conducted to form the basis for developing new concepts and perhaps new uses for peanuts and peanut proteins. In other in-house research, peanut constituents and their modification by processing that influence nutritive properties and consumer acceptance of processed peanut products are studied. A recently initiated phase of this research involves investigations of the proteins and nonglyceride lipid-soluble constituents of peanuts and processed peanut products. The Crops Research Division of ARS and several State Experiment Stations, including Georgia, Alabama, and Texas, cooperate in the research by providing samples of peanuts of known variety and of known growing, harvesting, and drying histories. Louisiana State University cooperates by conducting evaluation tests on selected peanut isolates. Additional research on chemical composition and properties is being carried out under contract at Evans Research and Development Corporation, New York, N. Y., on the isolation, identification and characterization of flavor and aroma components of processed peanut products to form the basis for producing improved peanut products of greater consumer acceptability.

The Federal in-house scientific research effort in this area totals 5.9 professional man-years. All of the present effort is on chemical composition and physical properties. The contract research involves an additional 1.0 man-years, all of the effort being on chemical composition and physical properties.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Chemical, Physical, and Biological Properties and Structural Factors of the Proteins. The composition, properties, structural factors and reactions of the proteins and associated materials of various seeds, including peanuts, are being investigated in a program of pioneering research conducted by the Seed Protein Pioneering Research Laboratory. Recent research has made significant contributions toward (1) a new classification of seed proteins, (2) new tools for the study of proteins, (3) a better understanding of the role of protein particles in seeds, and (4) elucidation of the role of lipolysis in mobilization of lipids in germinating seeds.

A major objective in the work has been to examine existing methods of classifying seed proteins and to provide the basis for development of new classifications which would have more meaning in terms of the function of the proteins in seeds. The present classification of seed proteins has been based upon solubility. This is artificial since it does not relate to any biological function of the proteins and has become increasingly unreliable as newer methods of analysis of proteins in mixtures, such as column chromatography and gel electrophoresis, have shown the various protein fractions to be grossly impure.

As the result of research in the Seed Protein Laboratory and other laboratories there now exists the basis for a new classification of seed proteins. It has been shown clearly that proteins exist in subcellular particles in seeds. In some seeds such as peanuts, soybean, and peas these particulate proteins comprise the majority of the protein. In others, such as wheat, they probably comprise a major portion of the proteins but not the majority. A uniqueness of seeds is that they contain a substantial amount of these particle-bound proteins. The new classification, based on protein bodies, provides a basis for simpler sources of the proteins and for eliminating the possibility of formation of artifacts during grinding of the entire tissue; for concentrating some of the components which are minor in the entire seed but are major components of subcellular particles; and it brings the field of seed proteins into the general field of seed biochemistry.

The Seed Protein Laboratory research has demonstrated clearly, both on the light and electron microscope level, the presence and morphology of protein bodies in peanuts and cottonseed. Moreover, by at least three different techniques, protein bodies were isolated from these two seeds and shown to

contain proteins, and even in some instances to contain fractions of the total proteins. The bodies not only stained for protein but were shown by isolation and chemical analysis to contain proteins.

As the point about subcellular distribution of seed proteins is now clearly established, research emphasis is being placed on (1) the isolation of pure seed proteins from particles, and (2) the biochemistry of the protein particles, and their role in development and germination of the seed.

New tools for the study of proteins have been developed in recent work. Included are new equipment and techniques for column electrophoresis on polyacrylamide gel, and for calorimetry.

In the previous report it was pointed out that polyacrylamide gel (Cyanogum gel) is very discriminating in separating protein components which are highly interacting. Electrophoresis on this gel of α-conarachin, shown pure by chromatography on DEAE cellulose and by sedimentation, indicated that it still contains about 10 to 15% impurities. It, therefore, was deemed advisable to develop equipment for more quantitative analytical analysis by electrophoresis on polyacrylamide gel and, eventually, for preparative electrophoresis using this medium. Equipment has been designed and built for analytical electrophoresis on a column of polyacrylamide. The protein is continuously eluted off the bottom of the column and is monitored by ultraviolet absorption. Bovine serum albumin was the model for development of this apparatus. This technique clearly shows the separation between the monomers and the dimers of bovine serum albumin; there is a strong possibility that it will also separate several of the monomers of this compound, which have defied separation heretofore. A design has been made of a multicolumn apparatus which will make possible preparative as well as analytical electrophoresis. It is the first time that it has been possible to observe electrophoresis in a medium through which no liquid will flow. It makes possible the study of the interesting properties of a completely crosslinked gel.

A microcalorimeter capable of detecting a change of one micro degree centigrade equivalent to one millicalorie has been constructed and is operating. It is intended for study of the structures of seed proteins. But first it is necessary to study the performance of this instrument on a well studied biological model. In cooperation with Dr. Eraldo Antonini and Dr. Jeffrey Wyman of the University of Rome, experiments are being conducted on the heat of protonation of human hemoglobin at various pH values. The results of this work have already attracted wide interest and are being reported at an international conference on calorimetry in Lund, Sweden.

Research has been conducted to develop information on the role of the protein particles, that is, to relate them to other biochemical properties of the seed. One major question involving oilseeds is the location of the lipids. It has generally been held that these are spread throughout the

cytoplasm of the parenchyma cells. Careful electron microscopy following staining designed to maintain lipids in place has now disclosed that lipids of the cottonseed are in two locations: within protein particles and in interparticle locations. These conclusions were reached by observing dense osmiophilic regions within the protein bodies and in the interbody space. They were confirmed by isolation of two particles from cottonseed cotyledons - a dense and light particle, both containing lipid. The isolation was accomplished by an entirely new approach of fixing the particles with tannic acid and then subjecting them to density separation. The heavy particles contain up to 30% lipids and the light ones up to 60%. It is now clear that the protein bodies are not completely protein-containing but are also associated with other material such as lipids. In previous reports it was pointed out that phytic acid was also located in some protein particles.

Another question was whether the resting seeds contain mitochondria. Mitochondria had been found in germinating seeds and in seeds which had been moistened for 12 hours, but had not been reported in the dry resting seeds. Suitable techniques of staining have now clearly shown that mitochondria are present in the resting seeds; some clusters of mitochondria under other staining techniques might even have been mistaken for protein bodies. There are, therefore, clusters of materials containing proteins which are not clearly protein bodies and which contain mitochondria and presumably other biologically-active membranous structures.

The association of proteins with storage materials and membranous structures might suggest that many of the proteins may have had an enzymatic function in the synthesis of storage material. The proper selection of enzyme tests might even show in the mature seed the vestiges of these enzyme systems. A second possible function for the proteins might be to serve as a matrix for the deposition of enzymes and other materials, similar to the function of structural protein of ribosomes, chloroplasts, or mitochondria. Another possibility is that some, at least, of the protein bodies represent organized systems of enzymes and substrates which participate in the synthesis of new enzymes in the early stages of germination. And finally there still may be some proteins which truly are reserves. Most proteins disappear from the storage tissue on germination. No matter what their function may have been initially, the same protein also serves eventually as a source of amino acids and nitrogen for the growing tissue of the seedling.

Further investigations have been made on the role of lypolysis in mobilization of lipids in germinating seeds. It is generally considered that lypolytic activity starts early in germination and that relatively large quantities of free fatty acids are formed. This information is based on rather flimsy evidence which includes titration of total acidity in germinating seeds without efforts to separate out the long chain fatty acids. Moreover, no efforts are made to inhibit enzymatic activity when the seed is ground to extract the free fatty acids. Therefore, it is entirely possible that the high free fatty acid content reported is actually an artifact of the method of measurement or of the method of disintegration

and extraction of the fatty acids. This is an important consideration because it has a bearing on the integration of activities in the mobilization of fats. It determines whether the lipase activity is an independent function in the seed or is closely integrated with the other activities involved in the breakdown of the fatty acids.

It has been found in the castor bean that the free fatty acid pool during germination is very low, 0.2 to 0.4 micromoles out of a possible 300 microequivalents present originally per kernel. This would mean that very little free fatty acid is present in the germinating seed at any given time. Although there is no lypolysis in the intact seed, once the seed is macerated there is very active lypolysis. This means that within the seed the system is so organized that no free fatty acids accumulate. Active work is now proceeding to determine whether the lipase may be isolated in a separate subcellular unit away from the other enzymes involved in fat mobilization.

2. Identification of Constituents and Factors Influencing Flavor, Aroma, Color, Structure, and Nutritive Value of Processed Products. Investigations have continued on the constituents of peanuts and their modification by processing that influence nutritive properties and consumer acceptance of peanut products. The myotonic factor in peanuts has been concentrated about 50,000-fold, but the pure substance has not been isolated. This material is physiologically active in concentrations of less than one part per million. Its activity is associated with a spectral absorption band at 5.65 microns. Loss of activity on mild hydrolysis is accompanied by the loss of this band, the appearance of a band at 7.4 microns, and the enhancement of the absorption band at 6.25 microns. This behavior might be accounted for by the opening of an unsaturated lactone ring to yield a compound having both acid and carbonyl groups.

A strong muscle relaxant has been isolated from the concentrates, along with additional crystalline substances that remain to be identified. Nicotinic acid and nicotinamide have been isolated and identified among the crystalline materials from the fractionation of the alcohol extract of defatted peanuts.

The use of peanut flour and peanut butter in hemophilia therapy appears to be expanding. Confirmation of the effectiveness of these peanut products for this purpose continue to be received.

The physiological tests on various peanut fractions isolated in the course of the research are carried out in the Department of Zoology at Louisiana State University. (S4 1-100).

A new line of basic research on peanuts, which will complement the work on characterization of alcohol-soluble constituents, was recently initiated. The influences of processing on the amino acid patterns of peanut proteins, as related to the properties of peanuts and peanut products, will be

determined. Non-glyceride lipid-soluble constituents of peanuts and processed peanut products will be isolated and identified. (S4 1-109).

Contract research is also in progress at Evans Research and Development Corporation, on the isolation, identification and characterization of flavor and aroma components of processed peanut products to form the basis for producing improved peanut products of greater consumer acceptability. (S4 1-106(C)).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

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New and Improved Processing Technology

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TUNG PROCESSING AND PRODUCTS
Southern Utilization Research and Development Div., ARS

Problem. Tung oil has lost much of its traditional market in protective coatings to synthetic raw materials. New and improved industrial products from tung oil must be developed to recapture lost markets, maintain present markets, and provide new outlets for surplus tung oil. Basic information is needed on the chemical composition and properties of tung oil and its fatty acids, and on the chemical modification of these materials to permit more effective exploitation of their unique characteristics in protective coatings, agricultural and industrial chemicals, surfactants, and plasticizers. For example, improved coatings utilizing tung oil are needed to meet increased performance demands and competition from synthetic polymeric coatings. Intumescing fire-retardant coatings and water-reducible coatings containing tung oil are desired. A limited market of low economic value exists for tung meal as a fertilizer. Research is needed to develop more information on profitable uses of tung meal to benefit the overall economy of the tung industry.

USDA PROGRAM

The Department has a continuing long-term program involving organic chemists engaged in both basic and applied research on tung and its products. Emphasis in the present program is on development of new and improved industrial products from tung oil and its derivatives.

Research is conducted at New Orleans, Louisiana, to develop fundamental information on the chemical composition, properties, structural factors, and reactions of oilseed proteins, as a basis for development of new concepts and possibly new uses for oilseed proteins.

Research to develop new and improved industrial products from tung oil is carried out at New Orleans, Louisiana, with cooperation and support by the Pan American Tung Research and Development League and the U. S. Army Engineers Research and Development Laboratories. The League maintains a part-time Fellow for research on the production of improved protective coatings. Major emphasis is placed on the development of exterior, intumescing fire-retardant surface coatings using tung oil alkyds. The tung alkyds are being chemically altered and formulations modified to produce coatings which will intumesce to give a thick cellular, fire-resistant material upon thermal or flame exposure. The U. S. Army Engineers evaluate the more promising fire-retardant coating formulations developed with their support. Other investigations involve studies of the chemical modification of tung oil and its fatty acids to produce chemical intermediates having utility in protective coatings, and as agricultural chemicals, surfactants or plasticizers. Informal cooperation is maintained with industrial firms and other agencies for the evaluation of promising chemical intermediates for specific end uses.

Other research in the area of chemical composition and physical properties is in progress under a grant of P. L. 480 funds to the National Chemical Laboratory, Poona, India, for investigations of the effect of heat on tung oil and its derivatives, and characterization and identification of compounds resulting from heat treatments, to extend the utilization of tung oil (project duration - 5 yrs.).

The Federal in-house scientific research effort in this area totals 6.4 professional man-years. Of this total 0.9 is devoted to chemical composition and physical properties, and 5.5 to new and improved industrial products. P. L. 480 research involves 1 grant for research on chemical composition and physical properties.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Structural Factors, Properties and Reactions of the Protein. The composition, properties, structural factors and reactions of oilseed proteins and associated materials are being investigated in a program of pioneering research conducted by the Seed Protein Pioneering Research Laboratory. The fundamental information developed should lead to new concepts and possibly new applications for oilseed proteins, including tung protein. Since peanuts were found to be an especially suitable experimental material and employed for much of the early pioneering research on seed proteins, the report of progress in the research is given in Area No. 7, "Peanuts Processing and Products," as in the previous report.

B. New and Improved Industrial Products

1. Intumescing Fire-Retardant Surface Coatings from Tung Oil Alkyds. Exterior and interior, intumescing fire-retardant coatings showing considerable promise are being developed from chemically modified tung oil-containing vehicles in research supported in part by the U. S. Army Engineers Research and Development Laboratories and the U. S. Air Force, and assisted by a part-time Fellow of the Pan American Tung Research and Development League. Paint films prepared from these new-type coatings produce a thick carbonaceous mass when subjected to flame and heat, thus insulating the coated material from being engulfed with flames. This has important implications, since more than 11,000 lives are lost annually in the United States by fire and our property losses by fire amount to over one billion dollars a year. Effective fire-retardant coatings should find use in civilian as well as defense applications, and could greatly reduce this loss of life and property.

Two of the better experimental exterior, intumescing fire-retardant paint formulations (which were developed from chemically modified domestic vegetable oils, chemically modified intermediates, and commercial paint ingredients) were modified to improve their can stability, brushability, drying

characteristics, color and tint retention, water resistance, weather resistance, spumific (foam-forming) and carbonific (carbon-forming) properties. Both of these formulations exhibited good fire retardancy when screened with the mild USAERDL fire-test cabinet and with the simple but severe SU screening test. Upon evaluation in the Forest Products Laboratory 8-foot tunnel furnace, performance of the formulations was not as good as desired but quite satisfactory for the present stage of development.

Recently a new formulation ("H") was prepared, in which a greater concentration of synthesized carbonific materials was successfully incorporated. It has exhibited improved fire retardancy, such as reduced flame-spread and heat-contributed index values, in comparison with earlier formulations. Paint films of formulation H gave excellent fire retardancy when evaluated in the USAERDL fire-test cabinet, good fire retardancy in the severe SU screening test and the Forest Products Laboratory 8-foot tunnel test, but unsatisfactory performance in the Underwriters' Laboratories 25-foot tunnel test. Failure in the latter test was apparently largely due to the evolution of too much gas from the films when they were subjected to the severe flame and heat. An elementary 8-foot tunnel furnace devised at SU is now being employed to screen new experimental coatings more efficiently prior to testing them in the 25-foot furnace. Attempts will be made to improve formulation H by reducing thermoplastic flow and gas evolution, and also to improve brushability. (S4 1-98).

2. Chemical Modification of Tung Oil to Produce New and Improved Products Such as Protective Coatings, Agricultural Chemicals, Surfactants and Plasticizers. In research on chemical modification of tung oil and its fatty acids to produce materials having industrial utility, attempts have been made to improve the surface active properties of tung monoglycerides for applications as fugitive emulsifiers. Difficulty was encountered in the sulfation of eleostearate monoglycerides utilizing the pyridine-SO_3, dioxane-SO_3 and sodium chloride-SO_3 complexes as well as chlorosulfonic and fuming sulfuric acids in various solvents. Maximum sulfation was only 10% of the theoretical, and a number of side reactions occurred to give a mixture of products having reduced unsaturation and properties not desirable for the use as fugitive emulsifiers. Other approaches than sulfation will be investigated. (S4 1-93).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

New and Improved Industrial Products

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1/ Publication resulting from research supported by funds transferred from the U. S. Army Engineers Research and Development Laboratories and the U. S. Air Force.

REPLACEMENT CROPS - UTILIZATION POTENTIAL
Southern Utilization Research and Development Div., ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available for their choice that would have different end-use patterns from those presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) Survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the U. S.; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of necessity for greater national self-sufficiency, the nation will benefit from availability of optimum, practical crop plants to serve its needs.

To achieve the objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potential. Work of the Department has already revealed several promising sources of new potentially valuable water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy unsaturated acids, capric acid, epoxidized acids and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants and on byproducts from processing, such as oilseed meals.

USDA PROGRAM

The Department has a continuing long-term program involving organic and analytical chemists engaged at New Orleans, Louisiana, in research to develop and evaluate industrial chemical products from the oils of certain new oilseed crops having production potentials as replacement crops. Oils from the seeds of the plants Limnanthes and Cuphea, rich in unusual long-chain unsaturated acids and capric acid, respectively, and from seeds of Umbelliferae such as parsley, carrots, fennel, dill, and coriander containing high percentages of petroselinic acid, are currently being investigated. The research is concerned with chemical modification of the oils and their

fatty acids to produce materials having potential utility in plastics, plasticizers, synthetic rubbers, protective coatings, and other industrial products.

Close cooperation is maintained with the New Crops Research Branch, Crops Research Division, in the procurement of seed and in joint evaluation of the potential of the new crops. The Pharmacology Laboratory of the Western Division, Albany, California, performs tests as needed to determine the physiological properties of the oils, their derivatives, and the meals. Louisiana State University cooperates by testing some of the chemical derivatives for antimicrobial activity. Other appropriate agencies in the Department of Agriculture and the State Agricultural Experiment Stations cooperate by evaluating the utility of some of the new compounds prepared from the oils. Informal cooperation is also maintained with industrial firms for evaluations of promising materials developed in the research.

The Federal scientific effort at the Southern Division devoted to research in this area totals 6.0 professional man-years. All of this effort is on industrial utilization.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Industrial Utilization

1. Industrial Products from Oilseeds Containing Capric and Unusual Long-Chain Unsaturated Acids. Investigations have continued on the chemical modification of new crop oils, and their fatty acids, from the seeds of the plants Limnanthes, Cuphea, and Umbelliferae to produce materials having utility in plastics, plasticizers, synthetic rubbers, protective coatings, and other industrial products.

Lactonization of L. douglasii fatty acids using perchloric acid catalyst was found to proceed satisfactorily, and other less potentially hazardous compounds are being screened as catalysts for the reaction. Gamma lactones produced in this manner should be interesting new chemical intermediates. Of a large number of additional compounds screened as catalysts for the lactonization of eicosenoic acid (a major fatty acid of L. douglasii), p-toluenesulfonic acid was the best although not as effective as perchloric acid. Fractional distillation of the methyl esters from L. douglasii oil yielded practically pure methyl eicosenoate. The distillation was accompanied by some double bond isomerization, resulting in the presence of isomers in the distilled methyl eicosenoate, but these isomers will not interfere with the intended preparation of the gamma-lactone from eicosenoic acid.

Screening of a number of chemical derivatives of capric acid (an important constituent of Cuphea seed oil) and other medium chain length acids showed that 4-(2-octenoyl)morpholide, 4-(2-nonenoyl)morpholide, 4-(2-decenoyl) morpholide, 4-(2-bromodecanoyl)morpholide, propargyl 2-bromodecanoate, and

2-(dodecenoyl)morpholide had good antimicrobial activity. These compounds have been submitted to the National Institutes of Health for screening as anticancer drugs.

In research on petroselinic acid (a major acid of Umbelliferae seed oil), methods for preparation of petroselinonitrile and petroselinamide have been improved. Reduction of the latter to petroselinylamine, reaction with acrylonitrile, and further reduction produced petroselinylamine-N-propylamine ("duomeen" petroselinate) in good yields. The "duomeen" compound may have potential as a corrosion inhibitor. Attempts are being made to form trimethylol compounds from aldehydes obtained by ozonization and reduction of petroselinic acid. These compounds should offer good possibilities for potential new uses.

Since fennel is one of the more promising crops for production of petroselinic acid, compositional information on samples of fennel seed and oil from Crops Research Division is being obtained to guide their research on development of this crop. Oil of fennel seed from different planting dates and spacings was found to average better than 70% in petroselinic acid content. Planting dates particularly affected oil content. (S5 5-45).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Industrial Utilization

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CASTOR, SAFFLOWER, AND OTHER WESTERN OILSEEDS - PROCESSING AND PRODUCTS

Western Utilization Research and Development Div., ARS

Problem. To provide valuable diversification crops for the acreage withdrawn from the production of cotton, wheat, feed grains, and other surplus crops, we must expand the markets for crops such as castor and safflower. But these crops are so new to our agricultural economy that their market potential has not been adequately developed. Castor and safflower have good potential because of the unusual properties of their oils. The possibility of large-scale increases in the production of these oilseeds would be strengthened if high-quality feed products could be developed from the oilseed meals. Basic information is needed on the composition of the oils and of the meals left after extraction of the oil, and this, in turn, requires the development of adequate analytical methodology. Rapid and accurate analytical methods are needed to control and improve the processing of the oils and meals for food, feed and industrial applications. Research on chemical conversion of the oils and evaluation of the modified products is needed to find new or improved large-volume uses. The high percentage of linoleic acid (essential fatty acid) in safflower oil points to a rapidly expanding use as a food oil. But this same fatty acid imparts a high susceptibility to autoxidation. Research is needed to stabilize safflower oil in various food products. Improved procedures for decorticating and processing castor and safflower seeds are needed. There is a particularly critical need to remove or destroy the allergenic and toxic components of castor meal which presently limit its use to fertilizer. Research to isolate and characterize the constituents in castor and safflower meals is needed to develop non-toxic, non-allergenic feed and food products of high value. Basic and applied research is needed to prepare chemically modified products from the meals for industrial applications, to develop economical procedures for carrying out the modifications, and to evaluate the modified products.

USDA PROGRAM

In the Western Utilization Research and Development Division, both basic and applied research are conducted on castor seed at the Division headquarters at Albany, California and, under contract, at Tucson, Arizona. Basic, compositional studies on castor seed meal are concerned with the resolution of its water-soluble proteins and determination of the allergenic and antigenic properties of these components. Studies are conducted on the composition of castor oil, and new analytical techniques are developed.

Applied research on castor meal has as its objective the development of economical methods for deallergenizing the meal without impairing its nutritive quality, to increase its value as an animal feed ingredient. Castor oil and its major constituent, ricinoleic acid, are being studied

to provide for them new and improved industrial applications. Thus, methods are being developed for the preparation of various types of polyurethane foams incorporating castor oil or its derivatives. Procedures are also being devised for the preparation of chemical derivatives of ricinoleic acid, including a number of amides and phosphate esters. Several of the latter compounds may be useful for improving the flame-resistance of castor-based polyurethane foams of the type which may be used for building insulation. The utility of various polymerizable monomers from castor oil for the production of synthetic polymers for use in rubbers, plastics, etc., is being investigated under contract.

The Federal program of research in this area totals 12.2 professional man-years, including contract research equivalent to approximately 0.3 professional man-years per year. Of this total, 2.8 are assigned to chemical composition and physical properties; and 9.4 to new and improved products and processing technologies.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Detection of Allergens. A risk-free and highly specific test for human allergy, with far-reaching implications for future medical practice and research, was developed in connection with research on allergy induced by castor seed proteins. Through the use of monkeys, the cost of allergy testing has been materially reduced and, more important, the hazards to human volunteers have been eliminated.

Informal cooperation has been maintained with Dr. Raphael Panzani of Marseille, France, who has been supported in part by the American castor oil industry. Reaginic sera of 26 castor-allergic patients from Marseille were tested, confirming the existence of multiple allergies to contaminants of castor pomace dust as well as to components of castor itself. Extensive tests with the sera from Dr. Panzani's allergic patients have unequivocally confirmed the value of the test procedure using monkeys. This new test for allergy provides the basis for solving problems caused by allergen sensitivity to castor and other agricultural products. In addition it promises to be a useful research technique not only in the study of all types of allergy, but also in other fields of medicine and biochemistry.

2. Allergenic Proteins. Chromatographic and electrophoretic separations of castor seed proteins and test for allergenicity indicated that castor seed proteins contain at least six specific antigenic compounds. Not all who are sensitive to castor meal are sensitive to the same antigen in the meal. Conclusive tests were conducted to show that cross-reactivity is involved. Castor pollen and blossoms can cause allergic reactions to pomace-sensitive persons. Furthermore, cross reactions were demonstrated with other members of the spurge family of plants. Contamination of castor

seeds with foreign materials is increased by mechanical harvesting, and contaminants were shown to complicate the allergy problem of castor seed pomace. It is now apparent that insects, molds, and weeds can cause allergic reactions and these foreign materials included in the oilseed pomace may promote sensitivity in humans working with it.

Some of the antigens isolated from castor seed meal have low molecular weights, probably less than 3,000. Low molecular weight antigens may be very potent allergens because the light molecules are easily inhaled into the deep recesses of the lungs, and hence easily absorbed into the blood. The wide distribution of low-molecular weight antigens through the blood stream to all the reactive organs involved in anaphylactic shock may account for the serious and sometimes fatal reaction in sensitized individuals. The existence of low-molecular weight antigens handicaps any deallergenation process involving hydrolytic cleavage of proteins. A successful process must degrade antigenic proteins to polypeptides of lower molecular weight than those occurring naturally in castor meal and capable of functioning as allergens.

B. New and Improved Products and Processing Technology

1. Chemical Derivatives. The ease of preparation of hydroxy-fatty acid amides in high yields and purity was reported previously and has already attracted industrial interest. One of the large castor oil companies is now making the diamide of ricinoleic acid and ethylene diamine as a direct extension of Department pioneering work on the preparation and characterization of a series of amides derivable from ricinoleic acid. The new amide synthesis has been extended to additional fatty hydroxy acids and applied to selected amino acid derivatives. Higher yields and increased optical purity have been achieved. Quarter-pound samples of several amide derivatives of ricinoleic acid have been made and are being evaluated for industrial application. Samples of vinyl-12-hydroxy-stearate, a derivative of castor oil, have been supplied for contract work on the development of polymers at the University of Arizona in Tucson.

2. Urethane Foams. Because of its high content of hydroxy-unsaturated fatty acid, castor oil and castor oil derivatives are useful in the preparation of urethane foams. The lowest cost urethanes can now be produced by employing a combination of castor oil and hydroxyl-containing amines. This formulation for urethane foams is based on Department research. Such foams have a very high insulating capacity and are particularly useful in construction where low thermal conductivity, high strength, and fire resistance are needed.

Flame resistant castor-based rigid foams were prepared using several commercially available fire retardants. Foams prepared with chlorinated castor oil had improved flame resistance and compressive properties as well. Fire retardants containing hydroxy groups react with the isocyanate of the urethane formulation and become part of the polymer when solvent-

blown, rigid urethane foams are prepared. Samples containing 10 to 15% of such retardants, produced self-extinguishing foams with compressive strength and other properties equivalent to controls. Non-reactive retardants produced foams with considerable loss of compressive strength.

The effect of aging on thermal conductivity of foams was investigated. After two months' aging, the desirable low thermal conductivity was retained in polyurethane samples based on both castor oil and polyethers if the polymer skin remained intact. Thermal conductivity increased somewhat if cut foams were aged for two months.

3. Animal Feed Meal. Deallergenized castor meal would constitute a suitable ingredient for livestock and poultry feeds and as such would command a higher price than it does as a general purpose agricultural fertilizer. Several chemical treatments which show promise for a deallergenating castor meal have been studied. Dilute ammonium hydroxide appears the most promising thus far studied. Such treatment is relatively mild, part of the ammonia may be recovered and reused, and the ammonia remaining in the pomace should benefit ruminant feeds.

On a very small-scale laboratory test, the allergens in wet castor seed pomace have been inactivated by ammonia at elevated pressures and temperatures. Non-allergenic pomaces have been tested with guinea pigs, monkeys, and castor-sensitive humans. Small amounts of isolated proteins from castor seed have been added to aliquots of extracts of such pomace. Amounts of allergens too low to cause reaction in humans could be detected in monkeys. With the cooperation of Dr. Panzani in Marseille, 60 of his patients were tested using the non-allergenic pomace and pomace that had been refortified with protein. It appears that correlations between human, monkey, and guinea pig reactions can be used to ascertain maximum safe levels for allergenicity. Such testing could be used to establish the safety of treated castor pomace.

Large-scale digestions of castor pomace have been attempted in a steam-jacketed digestion chamber using gaseous ammonia at 62 lbs. per square inch pressure and 145° C. Fifteen- to thirty-minute treatments gave considerable reduction of allergenicity. However, with 30 minutes of such severe treatment, a hardened, black, refractory material was produced. Further studies will be conducted to seek conditions on large scale that reproduce those of the small laboratory experiments in which successful deallergenation of castor pomace was achieved.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

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REPLACEMENT CROPS - UTILIZATION POTENTIAL
Western Utilization Research and Development Div., ARS

Problem. Farmers could achieve more economic use of their land if new and profitable crops were available that would have new end-use patterns. For example, it would be advantageous to develop a new oilseed crop yielding fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable. To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential; (2) detailed physical and chemical characterization of components of interest to obtain clues to likely end uses; (3) selection of the most promising species, followed by additional research to explore uses and demonstrate industrial potential, and by additional agronomic research to establish proper cultural practices and select the best strains and varieties. Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet, whether the future of agriculture involves conditions of surplus, of greater emphasis on foods and feeds, or of pressure for greater national self-sufficiency, the nation will benefit from availability of practical crop plants to serve its needs.

To achieve the objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potential. Work of the Department has already revealed several promising sources of new potentially valuable water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy-unsaturated acids, capric acid, epoxidized acids, and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants, and on by-products from processing, such as oilseed meals.

USDA PROGRAM

Basic and applied research is being conducted on hydroxy-unsaturated acid-containing oilseeds, in the Western Utilization Research and Development Division's headquarters laboratory at Albany, California; and by contract at Fargo, North Dakota. The basic, compositional studies emphasize the development of special analytical techniques for application to new oils containing hydroxy-unsaturated fatty acids. In the applied area, research is conducted to develop and evaluate industrial products from the hydroxy-unsaturated oils.

The Federal program of research in this area totals 4.0 professional man-years, including contract research at a rate equivalent to approximately 0.2 professional man-years per year. Of this total, 2.0 are assigned to chemical composition and physical properties; and 2.0 to industrial utilization.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Dimorphotheca and Lesquerella Seed Oils. Seed of the species Dimorphotheca sinuata are rich in an oil that contains dimorphocolic acid. The fatty acid composition of Dimorphotheca oil has been determined with isolations accomplished using partition, gas-liquid, and thin-layer chromatography and identifications involving ultraviolet, infrared, and nuclear magnetic resonance spectroscopy. About 2/3 of the fatty acid content of this oil is dimorphocolic acid, about 1/8 linoleic, and about 1/10 oleic acid. The presence of less than 1% of an epoxy acid has been definitely established by nuclear magnetic resonance analysis, and a hitherto unrecognized component, 9-keto,10,12-octadecadienoic acid, has been found in the amount of almost 2-1/2%.

Seeds of wild members of the mustard family, the Lesquerellas, are a source of two new fatty acids. Lesquerolic and densipolic acids have been found in two Lesquerella species and appear to have potential industrial uses. Lesquerella oils bear some similarity to castor oil, and are expected to have industrial uses in coatings, plastics, and chemical intermediates. Derivatives of Lesquerella oil have been made by high temperature pyrolysis of methyl lesquerolate in a procedure similar to that used to prepare derivatives of ricinoleic acid from castor oil. Good conversions of methyl lesquerolate to heptaldehyde and methyl tridecylenate have been obtained. Secondary decomposition products have been obtained also in small proportions. Conversion of the glycerol esters of fatty acids to methyl esters has been made substantially quantitative by using a high ratio of methanol-to-oil in a continuous system employing strongly basic ion exchange resins as catalysts.

These new derivatives of Lesquerella and Dimorphotheca oil are adding to the wealth of substances to be screened for industrial utilization.

B. Industrial Utilization

1. Industrial Products from Hydroxy-Unsaturated Oils. Continued preparation of new derivatives from Lesquerella and Dimorphotheca seed oils is beginning to provide novel compounds for industrial evaluation. Vinyl-9-hydroxy-stearate prepared from Dimorphotheca oil has been supplied for evaluation in making polymers at the University of Arizona in a contract research project. Long-chain phosphite esters of hydroxy fatty acids are being prepared for evaluation as plasticizers. A contract investigation has been initiated at North Dakota State University to evaluate the use of Lesquerella and Dimorphotheca oil derivatives in protective coatings.

REPLACEMENT CROPS - UTILIZATION POTENTIAL
EASTERN REGION
Eastern Utilization Research and Development Div., ARS

Problem. Farmers could achieve economic use of their land if new and profitable crops were available that would have different end-uses than crops presently grown. For example, it would be advantageous to develop a new oilseed crop yielding unique fatty acids that could find industrial use in applications for which acids from presently available domestic oilseed crops are unsuitable.

To develop a new crop, three basic steps are involved: (1) survey of wild plants, in cooperation with plant scientists, to identify those having both potentially valuable components and promising agronomic potential for use in the U.S.; (2) detailed physical and chemical characterization of components and basic research to obtain clues to likely end-uses; (3) selection of the most promising species, followed by additional utilization research to explore uses and demonstrate industrial potential and by additional agronomic research to establish proper cultural practices and select the best strains and varieties.

Only after these steps have been successfully accomplished can a proposed new crop be offered to agriculture and industry for introduction and development. Obviously, a program of this type is a long-range one. Yet such long-range research is necessary if agriculture and the nation are to benefit from availability of the best practical crop plants.

To achieve this objective, survey and characterization work needs to be greatly increased, since the greater the number of species examined, the greater will be the opportunities for finding plants meeting the criteria of high utilization and agronomic potential. Work of the Department has already revealed several promising sources of new potentially valuable water-soluble gums, pulp fibers, and oils containing unique fatty acids such as hydroxy unsaturated acids, capric acid, epoxy acids, and unusual long-chain fatty acids. In order to demonstrate the potential of these new materials, further work is required on their physical and chemical properties and reactions, on processing to obtain maximum recovery from source plants and on byproducts from processing, such as oilseed meals.

USDA PROGRAM

The Department has a continuing program involving chemists engaged in both basic and applied studies directed to the development of profitable new crops.

At Wyndmoor, Pa., work on new crops totals 7.2 professional man-years. Of this, 3.5 p.m.y. are devoted to study of the oil obtained from the seed of the Indian ironweed (Vernonia anthelmintica), in cooperation with the Northern Utilization Research and Development Division, the Crops Research Division and the Western Utilization Research and Development Division. The oil contains

epoxy fatty acids, potentially useful industrial chemicals.

An additional 3.7 p.m.y. are devoted, in cooperation with the Crops Research Division, to the assay of agronomic samples of Dioscorea tubers for their content of steroidal sapogenins, and to some supporting work on the assay of Canaigre tubers for their tannin content.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Utilization of Oilseeds Containing Epoxidized Oils

Whole Vernonia anthelmintica seeds can be stored at least 30 months in air at room temperature without change in composition of the oil. Domestic seed appears more difficult to extract than seed of Indian origin, and there are some differences in the composition of the oils.

The extraction procedure has been improved: the seed is first wet with petroleum naphtha, flaked wet, and rapidly extracted to give an oil with a minimum of free fatty acids.

The increasing interest of industry in the oil and its derivatives enhance the potential of the plant, and larger quantities of the oil, as well as pure trivernoln, 1,3-divernolin and vernolic acid are being prepared for testing by industry for use in plastics and other products. Vernolic acid is epoxy-oleic acid, $CH_3(CH_2)_4\underset{O}{CHCH}\ CH_2CH{=}CH(CH_2)_7COOH$.

B. Assay of Dioscorea and Canaigre

An additional 61 samples of Dioscorea spiculaflora, supplied by the Crops Research Division, were analyzed and the results reported to Crops Research for consolidation with the agronomic studies of that Division. Because of its gentrogenin content, this species is now sought in the commercial collection of uncultivated material. Gentrogenin is a good starting point for the synthesis of many drugs.

Since agronomic studies have now been completed, this work will soon be terminated.

The analysis of 137 samples of canaigre tuber supplied by Crops Research Division completed experimental work under this project and the project has been terminated. The collaboration with Crops Research resulted in the development of more than a dozen strains with a tannin content of 40% or better, with several having extract purities over 70. The highest one, a progeny of a genetic cross, was a sample containing 46% tannin with an extract purity of 73. A strain of this content and purity has a considerable potential as a replacement crop.

Selected samples will be preserved in a living germ plasm bank in Tonto National Forest, Arizona, and a few high-tannin, high-yielding varieties were planted in quantity, to permit rapid expansion in case of emergency. It has

been established that canaigre strains will retain their high level of tannin on repeated culture.

PUBLICATIONS AND PATENTS REPORTING RESULTS
OF USDA AND COOPERATIVE RESEARCH

Utilization of Oilseeds Containing Epoxidized Oils

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Assay of Dioscorea and Canaigre

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HUMAN NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done in Hyattsville, Md., and at Beltsville, Md.; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 66.3 man-years. It is estimated that approximately 2.7 man-years is concerned with studies related to oilseeds and peanuts.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 23.4 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to lipids are considered briefly in this report.

PROGRESS

A. Nutrient Values of Oilseeds and Peanuts

1. Tables of food composition. The 1963 revision of Agricultural Handbook No. 8, "Composition of Foods...Raw, Processed, Prepared" was prepared and carried through to the galley proof phase. Ten oilseeds and peanuts are included in the revision. With their various products, the total number of items in this category is about 60. This includes 3 classes of peanut butter with different amounts of added ingredients, peanut spread, 17 salad dressings, and 22 soybean products.

Data in the popular publication, "Nutritive Value of Foods," Home and Garden Bulletin No. 72, have been revised to agree on a weight basis with nutritive values in Handbook No. 8. The revised edition will provide nutritive values of household measures of 512 commonly used foods. Another popular publication, "Conserving Nutritive Value of Foods," Home and Garden Bulletin No. 90, is in press.

2. Vitamin analyses. Research continued on procedures useful for B-vitamin analyses to permit characterization of B-vitamins in foods such as soybeans and peanuts and to determine their overall distribution in the food supply. A procedure has been developed for the quantitative determination of pyridoxine (vitamin B6) as pyridoxal cyanohydrin. Studies will be continued to apply this chemical procedure to the assay of vitamin B_6 in food extracts and to verify results by comparisons with those of the microbiological assay. An improved method for thiamine determination has been developed. The conditions of the 6-aminothymol colorimetric reaction were changed so that a stable fluorescent compound was produced with thiamine. The fluorescence made possible measurements at much lower concentrations and appeared to be simpler than the usual thichrome reaction.

3. Lipids. The fatty acid composition of selected food fats has been determined using gas-liquid chromatography for separation of fatty acid esters. A manuscript was prepared presenting procedures of extraction resulting in minimal alteration in fatty acid composition.

Linoleic acid (18:2) comprised over 75 percent of the total fatty acids in safflower oil, 60 in cottonseed, 55 to 60 in corn and in soybean, 30 in peanut and 8 percent in olive oil. Linolenic acid (18:3) made up about 6 percent of the total fatty acids in soybean oil, 1.4 in corn and in olive oils, and about 1 percent in safflower and in peanut oils. Cottonseed oil contained little linolenic acid.

Linoleic acid was found to be some 26 percent of the total fatty acids in hydrogenated vegetable shortening currently available in retail markets, and 7.5 percent in mixed animal and vegetable shortening. Linolenic acid was almost 2 percent in hydrogenated vegetable shortening and 0.5 in the mixed animal and vegetable shortening.

Lipid biosynthesis is being studied as a possible criterion for assessing the nutritional value of foods. Rats developed acute deficiency symptoms when fed a cholesterol-free diet plus an inhibitor of cholesterol biosynthesis. The content of total sterols in their carcasses and tissues was about the same as for control animals fed a cholesterol-free diet. Analysis of the major sterols by Entomology Research Division showed 75 percent of the total sterols to be desmosterol and less than 20 percent to be cholesterol in the carcasses of the inhibitor-fed rats; in the carcasses of control rats 95 percent of the total sterols was found to be cholesterol. A manuscript presenting these findings has been accepted for publication. In other phases of this research, lipid biosynthesis in relation to age and diet is being investigated.

4. Proteins and amino acids. A manuscript was published describing a method for assay of alanine using Leuconostoc citrovorum 8081 and providing analysis of 48 proteins and foods including soybeans, peanuts, and peanut butter. Investigation of factors other than amino acids in food hydrolysates which affect the growth response of Leuconostoc mesenteroides P-60 was continued. Manuscripts presenting the results obtained are in preparation. Also studied was the effect of the type of carbohydrates in the basal medium on the essentiality of amino acids for growth of this organism.

Protein-rich mixtures of foods from vegetable sources are being developed and their nutritive values determined in contract research using Public Law 480 funds at Jerusalem, Israel. Wheat, flour, bulgur, soybean flour, chick peas, sesame flour, and sunflowerseed meal were analyzed for content of total nitrogen and of the three amino acids (lysine, methionine, and tryptophan) which limit the nutritive value of most plant proteins. The values obtained were used as a basis for preparing eight mixtures expected to have relatively high biological values. The nutritive value of the eight mixtures, each prepared to contain 25 percent protein, was assessed on rats by determining protein efficiency ratio, digestibility and biological value, and net protein ratio.

B. Properties Related to Quality and Consumer Use of Oilseeds and Peanuts

1. Shortening properties of fats. Investigation of the shortening properties of five kinds of fat -- corn oil margarine, hydrogenated vegetable fat, hydrogenated vegetable and animal fat, regular margarine, and butter at different levels of added fat, liquid, and sugar in white cakes is in progress. Sensory, physical, and chemical measurements are being used to determine the influence of the proportion and kind of fat on the quality of the baked product. A report on levels of fats and oils in pastry and biscuits was accepted for publication in Cereal Chemistry.

2. Use of agricultural chemicals. The flavor of roasted peanuts and of peanut butter made from Virginia Jumbo Runner 56R variety grown at Holland, Virginia, was evaluated to determine the effect, if any, of growing peanuts on phorate treated soil. Peanuts were grown in control plots and in plots treated with 2 pounds active ingredient per acre phorate (O,O-diethyl-S-(ethylthio)methyl phosphorodithioate), a systemic insecticide. A report on the results is in preparation.

C. Nutrient Functions

Lipids. A better understanding of specific relations between diet, health, and longevity has resulted from long-term investigations with laboratory animals fed 29 different experimental diets, including one that contains 20 percent peanut butter. Both excessive food intake and relationship or balance of nutrients in the diet are implicated in the adverse effects that occurred throughout the lifespan of laboratory animals. The studies indicate that genetic strain affects the response to the different diets and thus emphasize the importance of recognizing inherited characteristics in evaluating response to diets. Survival varied even with diets of similar fat and protein content. Differences in serum cholesterol levels of animals showed no relationship to kind or level of fat nor to level of dietary cholesterol.

Research on the effect of feeding rats, throughout their lifetime, diets containing fresh and oxidized olive and cottonseed oil was continued under contract in New York City. Structural analyses of triglycerides in the diets and in adipose tissue have shown that rats produced molecular types not present in the dietary fat although the structure of the depot fat was strongly influenced by the dietary fat. Oxidation of the dietary fats exerted only a mild effect on the structure of the depot fat triglycerides.

D. Human Metabolism

Manuscripts are being prepared for publication presenting results obtained in contract research at Los Angeles, California, on the effect of the type of dietary protein on the response to variations in dietary linoleic acid

and at Lincoln, Nebraska, and Battle Ground, Indiana, on the effect of the amount of dietary protein on the response to a constant amount of dietary linoleic acid.

E. Food Consumption and Diet Appraisal

1. Food consumption and dietary levels. A report of the findings of the food consumption survey of beneficiaries of Old Age and Survivors Insurance made in Rochester, New York in the spring of 1957 has been completed. The survey included 283 1- or 2-person households. During the survey week, food brought into the kitchens of these households averaged about the following amounts per person: 4 quarts of whole milk or its equivalent in milk products; 4 pounds of meat, poultry, fish; 1/2 dozen eggs; 10 pounds of vegetables and fruits; 2 pounds of grain products (in terms of flour); 1 pound of sugars and sweets; and 3/4 pound of fats and oils. The total money value of all food per person was $8.12. Nutrients from this food more than met the National Research Council's recommended allowance for the average person. However, less than half (44 percent) of the households had diets which met in full the recommended amounts for all nine nutrients (good diets). Nearly three-fourths of the households had diets that met two-thirds of the recommendations for all nutrients (good and fair diets). The nutrients which fell below the recommended allowances most often were thiamine and calcium.

The series of food surveys conducted in low-income areas to aid in the study of the effects of food distribution programs on diets of families has been extended to include a survey carried out in Choctaw County, Oklahoma and in Pensacola, Florida. These were conducted cooperatively with the Marketing Economics Division, Economic Research Service as were similar surveys reported previously.

A food consumption survey was carried out in the District of Columbia that will provide information on the diets of households and of individuals. The study was undertaken primarily as a pilot survey in developing procedures for the next Nationwide survey proposed in the Department's long-range program.

The nutrient content of the per capita food supply is calculated and published each year, using data on estimated quantities of foods consumed (retail-weight basis) as developed by the Economic Research Service. This series, with estimates extending back to 1909, is the only source of data on year-to-year changes in the nutrient content of the U. S. per capita food consumption. A comparison of the dietary fat provided by the individual foods within the fats and oils group in 1930 and 1962 revealed important changes. The proportion of dietary fat furnished by butter and lard in the fats and oils group decreased markedly--butter from 25 to 10 percent, and lard from 22 to 14 percent. These declines were compensated for by larger consumption of margarine, shortening, and salad and cooking oils. The proportion of dietary fat furnished by margarine rose from

4 percent in 1930 to 13 percent in 1962; by shortening, from 17 to 22 percent; by salad and cooking oils, from 10 to 20 percent. Special computations were made for fatty acids. Such estimates show that since 1930 there has been no significant change in the use of saturated fatty acids--the decrease in consumption of butter was offset by the increase in consumption of other foods, chiefly beef. The estimates, however, did show considerable increase in linoleic acid (an increase of 31 percent) as a result of the increased consumption of some foods rich in linoleic acid (salad and cooking oils, corn, cottonseed, soybean, and poultry).

2. Food management practices. The results from three small studies based on records kept by the homemaker on the kind, amount, and nutritive value of foods used and discarded in households have been prepared as a journal article. In terms of total calories available for consumption, discarded edible food averaged 7 percent in St. Paul, Minnesota; 8 percent in DeKalb County, Missouri; and 10 percent in Los Angeles, California. A study using "recall questions," instead of records, with a random sample of 300 households in Minneapolis-St. Paul in the winter of 1960 is currently being processed.

A report on household practices in handling and storing commercially frozen foods, based on surveys in two cities has been published. Survey findings indicate that household practices alone would not cause serious quality deterioration of frozen foods.

A new study has been initiated (under contract) of the management practices of urban and farm home freezer owners in Fort Wayne, Indiana and a nearby rural area. The survey is designed to obtain information on such actual management practices of home freezer owners as the kinds, amounts, sources, prices and rate of turnover of foods frozen and stored in the home.

3. Development of food budgets and other basic data for food and nutrition programs. The ongoing program of interpretation and application of nutrition research findings to practical problems for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education or nutrition policies has involved the preparation or review of articles and publications, talks, television interviews, and participation in various conferences and committees.

With the publication of the report "Family Food Plans and Food Costs" the technical work on the development of the Department's current low-cost, moderate-cost and liberal food plans was completed. The continuing phases of the work on individual and household food budgets consists in the regular pricing of the food plans for publication in Family Economics Review, and in dissemination of information concerning them through such

popular publications as "Family Food Budgeting for Good Meals and Good Nutrition," through filmstrips ("Food for the Young Couple"), and through correspondence, talks and committees (such as the Advisory Committee to the Bureau of Labor Statistics on their City Workers' Standard Budget).

Progress on the revision of Handbook No. 16, "Planning Food for Institutions" has focused primarily on the food purchasing guide section. Publications in preparation that are designed for the use of teachers, extension workers and other leaders are (1) a semi-popular publication on nutrition in the series Facts for Nutrition Programs; (2) a report on fat and related components in U.S. diets; and (3) a study of the relative economy of foods.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides one channel for disseminating pertinent information and for reporting nutrition education activities. Examples of subjects of current interest covered during the report period are: "Nutrition Aspects of Selected Studies of Cardiovascular Diseases--Implications for Nutrition Education," "Planning Nutrition Programs for Elementary School Teachers," and "Food Guides--A Teaching Tool in Nutrition Education."

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OILSEEDS AND PEANUTS - MARKET QUALITY

Market Quality Research Division, AMS

Problem.

Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus damage and contamination, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various species of insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization procedures.

The demonstrated development of resistance to pyrethrum and malathion by stored-peanut insects, either in the laboratory or in the field, jeopardizes the future of the treatments now used for protecting stored farmers' stock peanuts. This indicates the urgency for developing new preventive or control measures, because it is impossible to predict how soon current measures may become ineffective. There is also a need to study the nature of insect problems in peanut shelling plants and to develop effective measures for preventing insect infestation and damage at this stage of handling.

USDA PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods for quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C.; research on peanuts is done at Raleigh, North Carolina, in cooperation with the North Carolina State College and Federal-State Inspection Service, at Albany, Georgia, in cooperation with the University of Georgia, and also by research contract with Texas A & M, College Station, Texas.

A P.L. 480 grant with the College of Agriculture, Olsztyn, Poland, provides for a study of storage changes in flaxseed. Its duration is 4 years, 1960-1964, and involves P.L. 480 funds with an $18,127 equivalent in Polish zlotys.

A P.L. 480 grant with Universita Di Firenze, Institute OI Industrie Agrone Il Direttore, Florence, Italy, provides for a study of the effect of different types of containers on long-time bulk storage on the quality of vegetable oils, and to examine the natural antioxidants and their effect upon the quality of the oil. Its duration is 5 years, 1962-1967, and involves P.L. 480 funds with an $26,344.61 equivalent in Italian lires.

The Federal scientific effort devoted to research in this area totals 5.3 professional man-years. Of this number 4.3 are devoted to quality evaluation and 1.0 to quality maintenance.

The Department also has a continuing long-term program at Tifton and Savannah, Georgia, involving entomologists engaged in basic and applied research on problems of insect infestation, damage, and contamination of peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service of this Department, growers' cooperative associations, and various industry groups.

A continuing program of basic and developmental studies at Savannah, Georgia, involves entomologists and chemists whose research has cross-commodity application. Much of the work has a direct or indirect relation to oilseeds and peanuts but only a part of the effort has been charged to Area 3.

The Federal scientific effort devoted to entomological research totals 3.7 man-years divided as follows: Insecticide evaluation 0.2, insecticidal control 0.2, and nonchemical control 0.6 at Tifton; insecticide evaluation 0.6, insecticide residue analysis 0.5, and nonchemical control 1.2 at Savannah; and program supervision 0.4 at Hyattsville, Maryland.

Line Project MQ 1-14, "Evaluation of protective sprays and dusts for preventing insect damage to stored farmers stock peanuts," was discontinued.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Methods and Equipment for Grading Farmers' Stock Peanuts. The pneumatic samplers for peanuts, developed under this project, have been installed at 165 buying points in the Southeastern peanut growing area.

Mechanization of the sampling, shelling, splitting, and sizing operations in the grading process for farmers' stock peanuts has enabled the use of larger, more representative samples. The size of the grading sample is still limited, however, due to the amount of time required to hand-clean the samples for foreign-material determinations. An improved model of the sample cleaner which was tested in 1962 has been constructed and is being tested by the Federal-State Inspection Service during the 1963 marketing season. A complete set of working drawings on the machine have been prepared.

Peanut kernels are screened during the grading operation and the percent of kernels that ride certain screens is an important grade factor. Studies have shown that the moisture content of the kernels as well as the method of curing them will have an effect upon this percentage. Slow drying during the curing process and high moisture content at time of screening tend to increase the percentage while rapid drying and low moisture contents decrease it.

It is important to note that peanut kernels are not symmetrical and the screening process measures the shortest dimension of the kernel, not its size or volume. Density measurements have indicated that although rapid drying decreases the shortest dimension of the peanut kernel it also increases the volume or size of the kernel.

(MQ 3-29)

2. Evaluation of Damage Factors in Peanuts. Studies have shown that off-flavors are produced in peanuts when they are cured in the absence of oxygen. Peanuts cured in atmospheres of nitrogen at 100° F. have off-flavors quite similar to off-flavors produced in peanuts cured in normal atmospheres at 125° F. Respiration studies have been made on mature and immature peanuts curing at 95° F. and 125° F. These studies indicate that anaerobic respiration occurs under the same conditions that produce off-flavors in peanuts. The quantity of CO_2 evolved by

anaerobic pathways during a given curing treatment appears to closely parallel the amount of off-flavor produced in peanuts by that curing treatment.

Samples of peanuts cured by three different methods and harvested on three different dates were submitted to three leading manufacturers of peanut butter for taste panel evaluations. The results of the tests indicate that time of harvest as well as curing treatment had considerable influence on the flavor of peanut butter produced from the peanuts. The marked disagreements among the evaluations made on identical samples by the different laboratories emphasize the need for a universal quality standard within the peanut industry for flavor evaluation of farmers' stock peanuts.

(MQ 3-26(c))

B. Quality maintenance in storage

1. Flaxseed Storage. Under P.L. 480 grant in Poland, research on the influence of storage changes on quality of seed and properties of linseed oil has been underway for three years. The initial phases of the studies have been completed and included a study of the composition of seed of different varieties grown in several areas and at several stages of maturity. Different methods of analysis were evaluated in order to demonstrate that test data can provide the best measure of changes in quality during the storage of the seed.

(E21-AMS-6)

2. Soybean Oil Storage. A 4-year study of the effect of long-time storage of soybean oils under simulated commercial conditions was completed. Crude, degummed and refined soybean oils were stored at Beltsville, Maryland. Time-temperature relationships will be derived from data obtained in this study whereby predictions can be made of quality of oils after any length of storage at any known location.

(MQ 2-44)

3. Natural Antioxidants in Vegetable Oil Storage. Work was initiated on the effect of added natural antioxidants and synergists on refined vegetable oils in storage. Refined oils with added natural antioxidants will remain in storage at several constant temperatures over a 3-year period in order to determine the efficacy of these substances and relate the rate of change in quality to data previously obtained on stored refined oils.

(MQ 3-25)

4. Vegetable Oil Storage. A study has been initiated under a P.L. 480 grant in Florence, Italy, to investigate the effect of different types of containers on long-time bulk storage on the quality of vegetable oils, and to examine the natural antioxidants and their effect upon the quality of the oil. Some commercially available antioxidants will also be evaluated. This project was initiated during the past year, using cottonseed, soybean, peanut, sesame, and olive oils.

(E15-AMS-12(k))

C. Prevention of insect infestation

1. Insecticide Evaluation. Preliminary tests were conducted at Tifton to develop a technique for the application of candidate insecticides to commodities for preliminary laboratory evaluation. An 8-quart twin shell liquid-solid V-type blender reported to be highly suitable for this type of application was procured and tested. Malathion was applied to farmers' stock peanuts at five different rates and with six different batch sizes in the blender. Results of chemical analyses revealed that malathion deposited on the peanuts averaged less than 30 percent of that added in the blender. It was decided all stations would use a simple tumbling technique evaluated and found effective at the Savannah station for applying candidate insecticides to commodities for the evaluations to be conducted under this project.

(MQ 1-15)

A few compounds found promising at Savannah under Line Project MQ 1-23, were applied to farmers' stock peanuts and tested at Tifton against confused flour beetles in laboratory evaluations. One of the three compounds tried rated higher on initial toxicity than the standard malathion treatment. The test is continuing to determine the duration of residual effectiveness.

(MQ 1-15)

Exploratory fumigation tests were conducted at Savannah with methyl bromide. Adult red flour beetles were exposed 24 hours at 80° F. ±4° in 20-liter bottles 3/4 full of farmers' stock or shelled runner peanuts. The lowest dosages producing 100-percent mortality were 8 mg./liter in farmers' stock and 14 mg./liter in shelled peanuts. Inorganic bromide residues resulting from methyl bromide dosages of 2 to 10 mg./liter ranged from 5.1 to 12.0 p.p.m. in shelled peanuts and 7.3 to 20.0 p.p.m. in farmers' stock peanuts. (Exploratory, prior to establishing line project.)

Much of the cross commodity insecticide evaluation work at Savannah has application to peanuts but the entire report is included in Area 13.

2. Insecticidal Control. The malathion bulk treatment for farmers' stock peanuts, applied at the time of storage, supplemented by periodic surface treatments during storage, was developed by research as reported previously. It was found to be the most effective and most economical treatment yet available for protecting stored peanuts. It is used extensively by the peanut industry, and is included in the storage contract for government-owned peanuts. A survey of storage warehouses was made following reports that the malathion treatment was failing to control insects in the 1962 crop. It was found that in some cases the malathion spray had not been applied properly at the time of load-in. In other cases the surface sprays had not been started soon enough or had been improperly applied. More warehouses had moth infestations on the surface of the peanuts this year than last year at the same time. The Ephestia moths were more prevalent than the Indianmeal moth, whereas the two have been about equally abundant in peanut warehouses in the past. There were fewer beetles found in the stored peanuts than in former years.

(MQ 1-14)

Moths collected from peanut storage warehouses where malathion treatments had been used for 1 to 3 years were taken to Savannah to find whether malathion resistance may have developed. Cultures were established and contact toxicity tests were conducted with malathion against larvae. Strains of both Ephestia and Indianmeal moth larvae from the peanut warehouses were less susceptible to malathion than were those from sources without previous exposure to malathion. Observations are continuing to determine the degree of tolerance to malathion and whether it is sufficient to prevent adequate practical control.

(MQ 1-14)

Samples of peanuts were collected from some warehouses and were sent to Savannah for malathion analyses. The malathion deposits were very erratic from one warehouse to another, ranging from a low of 2.1 p.p.m. on probe samples to a high of 454.7 p.p.m. on surface samples taken soon after spray application. There was not adequate opportunity to check up in detail but it appeared that low deposit levels could usually be attributed to improper application. An extra malathion surface spray, to be applied in

December 1962, was authorized for all warehouses where it was needed for moth control. The regularly scheduled surface sprays kept the moths under control for the remainder of the storage season. Peanuts from only a few warehouses had any appreciable amount of insect damage at the time of load-out.

(MQ 1-14)

3. Insecticide Residue Analysis. Some residue information is included in the discussion of preceding items. The overall residue analysis program conducted at Savannah, Georgia, is reported in Area 13.

4. Nonchemical Control. Treatments recently developed by research have made it possible for farmers' stock peanuts to come out of storage almost completely free of insect damage and contamination. Since shelling plants are the next step in the movement of peanuts through the marketing channels, a question was raised as to their possible implication in cases where shelled peanuts are damaged or infested when they reach the customer. An exploratory investigation of shelling plants has revealed many insects that attack shelled peanuts do develop in the trash and broken kernels that may be permitted to accumulate in peanut handling and shelling machinery and around the plant itself. A total of 12 different kinds of stored-product insects was found in small samples of trash collected in different parts of a single shelling plant during one inspection. The most abundant insects were almond moth larvae, followed in order of abundance by corn sap beetles, flat grain beetles, and red flour beetles, with smaller numbers of the other eight species. These insects could provide a ready source for infesting peanuts as they pass through the shelling machinery or as they are held in the plant prior to shipment. (Exploratory, preliminary to establishing a line project.)

Research to develop effective methods for preventing insect infestation in stored peanuts without the use of pesticidal chemicals has been initiated. Tests to establish the time-mortality regression lines for red flour beetle adults and Indianmeal moth larvae exposed to pure nitrogen or carbon dioxide were completed. The red flour beetle adults were more susceptible to both gases, and nitrogen was more effective than carbon dioxide against both species. Preliminary results from studies currently in progress indicate (1) the viability of peanuts is not affected by storage for 3 months in high concentrations of nitrogen or carbon dioxide, (2) the oxygen concentration in the

atmosphere of hermetically sealed peanuts decreases below the level required to support the life of insects that infest stored peanuts, and (3) carbon dioxide is more efficient than nitrogen in purging oxygen from columns of peanuts. (Exploratory, preliminary to establishing a line project.)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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MARKETING FACILITIES EQUIPMENT AND METHODS
Transportation and Facilities Research Div., AMS

Problem. Differences in varieties of oilseeds and peanuts and in the environments of producting areas where they are conditioned and stored, together with advancing techniques in cultural and harvesting practices, require new or modified marketing facilities, equipment, and methods. Such changes are essential to efficient and economical handling, conditioning, and storing these crops and to maintaining their quality. There is a need for improved designs of facilities based on functional and structural requirements, which will expedite the movement of commodities into, within, and out of the facility. There is also a need for handling and conditioning equipment which will minimize labor and other costs. More knowledge is needed of the relative efficiency of various handling and conditioning methods so that improved or revised methods and equipment can be developed to perform necessary operations.

USDA PROGRAM

The Department has a long-term program involving both applied and basic research as well as application of known principles to the solution of problems of handling, storing, and conditioning field crops in marketing channels. Research on the handling, drying, aerating, and shelling of peanuts is conducted by the Albany, Ga., field office at laboratory and pilot-scale facilities in Dawson and Bainbridge, Georgia, in cooperation with the Georgia Agricultural Experiment Stations, and with various industry firms. The Federal effort devoted to research in this area totals 3.9 professional man-years to handling, drying, aerating, and storing peanuts.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Shelling, Handling, Drying, Aerating, and Storing Peanuts

1. Shelling. An experimental pilot-scale peanut shelling plant was established at Dawson, Ga., in the fall of 1962. This plant provides facilities for obtaining much needed engineering research data for developing improved machinery and operating methods for shelling, cleaning, and sorting peanuts. There is a difference of roughly 10 cents per pound between peanuts grading No. 2 and those going into oil stock because of splits and broken kernels. Therefore, sheller operators need reliable research results to aid them in operating shellers to produce as many whole kernel peanuts as is practical.

About 83 tons of peanuts were shelled during the 1962-63 season. Included were Spanish, Runner, and Virginia type peanuts obtained from the three producing areas; the Southwest, Southeast, and Virginia-Carolina.

Limited tests indicated that a sheller speed of 290 RPM commonly recommended and used by the trade is not in many cases the optimum speed. For example, sheller speeds of 210 to 265 RPM gave a better outturn of whole kernel peanuts when shelling lots from the three producing areas than a speed of 290 RPM. Also, tests to date give good evidence that sheller speeds should be varied between sheller stages for best results. A major problem in a shelling plant is the removal of foreign material from the peanuts. Modifications have already been made in cleaning equipment in the plant that increased the total amount of foreign material removed from 5 percent up to 70 percent.

2. Handling. Tests with a pneumatic conveying system for handling farmers stock peanuts were continued at Bainbridge, Ga., using air velocities of 5,400, 6,300, 6,600 and 7,600 feet per minute (fpm). Physical damage to the peanuts increased from about 7 percent at 5,400 to about 13.5 percent at 7,600 fpm. The speed of the air-lock valve in the conveyor also is important with a maximum total damage of over 25.5 percent occurring at the higher valve speeds used in the tests.

3. Drying. A total of 42 tests were run in the experimental drying unit at Bainbridge, Ga., during the 1962-63 drying season using Spanish, Runner, and Virginia type peanuts. Generally, about twice as much water was removed per hour when using an air velocity of 100 feet per minute as was removed when using 50 feet per minute when the temperature of the drying air was 125° F. and above. The actual temperature of the kernels did not reach the temperature of the drying air until the moisture in the peanuts was reduced almost to the desired moisture level of 7 percent.

Generally, the number of sound splits was greater when high drying-air temperatures or high airflow rates were used, or when drying was started with peanuts at a high moisture content. For example, there were twice as many sound splits when using an air velocity of 100 feet per minute as compared to using 50 feet per minute when a drying-air temperature of 140° F. was used. The percentage of sound splits was about 5 times greater when dried at 140° F. as compared to drying at 125° F. (air velocity 100 feet). When peanuts with moistures above 35 percent were dried using air temperatures above 130° F. the increase in sound splits, skin slippage, and off-flavor was usually about twice as great as when peanuts with lower moistures were dried with air temperatures below 130° F.

4. Aeration. Tests with stored farmers stock peanuts were continued at Bainbridge, Blakely, and Columbus, Ga. Results of last year's tests indicated that the moisture loss from the stored peanuts at Bainbridge was less than 1/2 percent; at Blakely about 1/2 percent; and at Columbus slightly more than 3/4 percent. At Columbus, a comparison was made between aerated and non-aerated stored peanuts. The moisture loss in the non-aerated peanuts amounted to slightly more than 1 percent as compared to 3/4 percent in the aerated peanuts. At the current price of peanuts the additional weight retained in the aerated peanuts represented $1,300 in additional revenue to the storage firm.

ECONOMICS OF MARKETING
Marketing Economics Research Div., ERS

Problem. Most agricultural processing industries are experiencing rapid and drastic changes in their market organization and practices. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducting costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economies of scale and efficiencies possible in the marketing of farm products.

Market research also is increasingly concerned with evaluating present and prospective programs pertaining to agriculture, such as the Food Stamp Program and Federal Grading Activities and to the changing structure of market industries as this may influence the bargaining power of farmers. Marketing Research also is being directed to the economics of transportation and storage activities of both private firms and Government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Development Program and in assessing prospective inter-regional shifts in the areas of production and marketing for specific products.

USDA PROGRAM

The Department has a continuing long-term program in research to bridge the gap between laboratory developments and commercial adoption so as to fully assist producers to realize more rapidly and more fully benefits of lowered costs, increased returns, and expanded markets that new products and new uses can afford. Research is carried on in industrial and food uses at Washington, D. C., and field offices. The Federal scientific effort devoted to research in this area totals about 20.5 man-years. Of this number, approximately 2.5 are engaged in research on oilseeds and peanuts.

Research in the area of marketing margins, costs, and efficiency is designed primarily to provide useful information on the amounts and trends in marketing margins, costs of marketing, labor and equipment requirements, cost standards, economies of scale, and other factors including marketing practices, affecting costs of marketing through all important trade channels and types of firms and for all farm products marketed in commercial volumes. In nearly all studies close cooperation is maintained with industry and trade groups and with individual private firms

that generously provide essential data from their records and make their plant facilities available for observation and the conduct of various market tests. Although most of the research is conducted by personnel in Washington, D. C., a considerable part of the work is done by USDA professional staff located at field stations in several states. The USDA scientific effort devoted to research in this area, including cooperative agents paid mainly from Federal funds, total 42.2 professional man-years. Of this number, 3.5 to oilseeds and peanuts.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Market Potential for New Products and New Uses.

Oilseeds. Qualitative assessment of industrial uses for fats and oils are necessary to determine the economic and technical conditions for market improvement or maintenance in view of competition from synthetic products.

A study of detergents and other surfactants found that about 50 percent of the surfactants produced in the United States are used as detergents. The number of fat-derived surfactant applications is growing, and the volume of these surfactants is likewise increasing. Non-household detergent usage of surfactants has increased faster than household detergent usage; a trend that has been underway for several years.

The resolution of present problems of detergent foam as pollution in fresh water supplies is not expected to have a large effect on marketing fats and oils. The price competition among raw materials for detergents that would lessen this problem is not such as to be strongly attractive to fats and oils.

Most detergent producers did not expect to use synthetics as replacements for natural fatty acids and alcohols in present uses until they were lower in price or offered capabilities not obtainable from fat or oil derived alcohol.

Market assessments are continuing on detergents and other surfactants, polyurethane products, fatty nitrogen compounds, synthetic rubber, surface coatings, and greases, metallic soaps and metal fabrication.

2. Markets for modified edible fats and oils products in four specific food fat and oil areas of application were studied - emulsifiers, confectionery fats, protective coatings, and edible lubricants. Improved emulsifiers probably would not extend fats and oils use but could lead to better end products. Improved confectionery fats could largely displace cocoa butter and improved protective coatings can meet needs not now fulfilled. Modest increases may also come from improved food lubricants. Gains in these latter three areas of application from improved products could approximate 75 million pounds of fats and oils per year within the next 5 years.

3. Some areas of the country are large producers of soybeans and users of soybean meal, but because of lack of processing facilities, locally produced meal is not available. Lower freight costs, due to local soybean processing of unextracted meal could amount to substantial savings and would enable feed manufacturers to produce a high-fat feed without special handling equipment. Economic feasibility of using unextracted soybean meal depends upon the price relationships between tallow and grease and soybean oil.

Case studies of poultry feeds made by 19 feed mills in northwest Arkansas, Delmarva, and north Georgia poultry areas show that at the time of the study, cooked unextracted soybean meal was commercially acceptable and economically justified. Potential cost savings, exclusive of processing costs for making cooked, unextracted meal ranged from $2.28 to $13.51 per ton of soybeans with most feeds, well above the lowest level of $2.28 per ton. These savings would have been available to cover costs such as milling or flaking, cooking and drying of meal, plus profits to processor.

B. Marketing Costs, Margins, and Efficiency.

Oilseeds and Peanuts.

1. Marketing Margins for Fats and Oils. The major shifts in the utilization of various types of fats and oils in recent years created considerable marketing problems for agencies assembling, processing and distributing these products. A study of trends in marketing spreads for various fats, oils and oilseeds used in food and nonfood products provides valuable information to many farmers and marketing agencies to adjust efficiently to the changing conditions of markets.

Background information is being developed relating to the importance of various food products in the utilization of edible vegetable oils. Data are also being compiled for estimating "farm values" for the oils that have recently come into wider use in food products. Retail prices arranged for the B. L. S. are now being regularly received. No findings are available as yet.

2. Marketing Margins for Peanuts in Peanut Butter. Peanut butter is the primary product made from peanuts. In 1960, retail prices of a 12-ounce jar of peanut butter averaged 41.8 cents, of which the grower received an average of 11.8 cents. This farm-retail price spread was divided as follows: shellers, 21 cents; manufacturers, 15.0 cents, wholesalers and retailers, 12.9 cents. Chainstore margins averaged 2 cents a jar below margins in other stores. Margins on minor brands averaged 8 cents a jar below margins on the major brands requesting, in large part, the higher cost of advertising and merchandising the nationally advertised brands.

3. Costs and Practices of Peanut Shellers. Peanut shellers are under considerable pressure to increase their efficiency and lower cost of marketing. The adjustment of the shelling industry has been to larger and fewer firms, and toward integration with manufacturers and distributors of peanut products and other foods. Shellers have also moved rapidly toward bulk handling and storing of farmers stock peanuts in all major producing areas. However, in the Southeast, this adjustment is far from complete.

4. Sheller Margins. A part of this project involves special research relating to the establishment of differentials under the price-support program for peanuts. The second phase, now nearing completion, involves the development of a uniform accounting system for peanut shellers. This accounting system will facilitate a more equitable determination of sheller margins for the several types of peanuts, and will aid shellers in their own efforts toward increasing the efficiency of their operations.

5. Commercial Utilization Pattern and Pricing of Peanuts. Under the price-support program, peanut shellers have a difficult problem in determining what qualities of peanuts they should endeavor to buy. Their problem is to determine the interrelation of kernel grade characteristics, the grade kernel support price, shelling costs, and the outturn of shelled grades to profits on a given lot of farmers stock peanuts. A linear programming model has been developed to determine the optimum quality of farmers stock peanuts that shellers should buy under varying assumptions and marketing conditions. Good progress has been made in obtaining the necessary data for the model including estimates of shelling costs. Results of this study also should be of considerable value to administrators responsible for establishing price supports.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Market Potential for New Products and New Uses

Doty, Harry O. Jr., February 1963, The uses and future of oilseed crops in the West, Regional Safflower Conference, Logan, Utah (speech)

Marketing Costs, Margins and Efficiency

Farnworth, Virginia M. August 1963. Margarine prices and advertising. Article in Developments in Marketing Spreads for Agricultural Products in 1962, ERS-14.

COOPERATIVE MARKETING
Marketing Division, FCS

Problem: Farmers continue to expand their use of cooperatives in marketing the products of their farms. In light of the rapid and complex changes taking place in technology and in market organization and practices, research is needed to help farmer cooperatives and other marketing agencies perform needed marketing services both more efficiently and more effectively. Farmer-directors, managers and others, including the public, need more information to assist in making decisions on how cooperatives can maintain and strengthen the bargaining power of farmers, increase efficiency and reduce costs of marketing, and better meet the needs of our mass distribution system for large quantities of products on a specification basis.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting farmers' marketing problems in our modern, dynamic system. They are organized and operated to increase farmers' net income. However, cooperatives face many problems in achieving this goal. Cooperatives must find ways to consolidate volume, for example, through internal growth, merger, acquisition or federation, to strengthen their market position and meet the needs of mass merchandising. Ways must be found to reduce costs by increasing efficiency through improved operating methods, better organization and management, and more use of new technologies.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D. C. Many of the studies, however, are done in cooperation with various State Experiment Stations, Extension Services, and Departments of Agriculture.

The number of Federal professional man-years devoted to research in this area totals 21.2, of which 1.3 man-years are on the cooperative marketing of oilseeds and peanuts.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Oilseeds and Peanuts

1. Marketing farmers' stock peanuts. Work was completed on an evaluation of present and possible alternative methods of marketing farmers'

stock peanuts in the Virginia-North Carolina area. A report was issued on growers' marketing methods, and one on the methods and practices of first-buyers. These studies indicated that peanut-buying is generally a part-time operation, integrated with other services; rapid expansion in efficient bulk handling facilities can be expected; and changes in marketing facilities must reflect the high concentration of small sales per farm and growers' lack of transportation and bulk storage facilities. A third phase of this work examined the economies associated with size and location of bulk facilities and alternative bulk handling techniques. Adjustments in present grower harvesting, storage, transporting and selling practices were suggested, and models to serve as guides in changing from bag to bulk handling were developed. A report covering the results and implications of this analysis and its relationship to earlier work conducted under this project is in preparation. This study has been carried on jointly under contract with North Carolina State College.

2. Efficiency of cooperative soybean processing. Work continues with cooperative soybean processors in attempting to improve efficiency, reduce costs and increase returns to growers. Operating information and problems are discussed at an annual meeting of officials of the cooperatives concerned. Based on the work and experience with these cooperative processors, four requests were handled during the year on the feasibility of constructing and operating processing plants.

Continued to work with directors and officials of a federated sales agency whose membership is made up of cooperative soybean and cottonseed processors. A sales office has been established in Chicago.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Biggs, G. W., King, R. A., and Jones, E. W. 1962. Buying Farmers' Stock Peanuts in the Virginia-North Carolina Area. Marketing Research Report 555.

Biggs, G. W. July 1963. Peanuts--No Longer Just Peanuts. Article in News for Farmer Cooperatives.

Jones, E. W., King, R. A., and Biggs, G. W. 1963. Marketing Farmers' Stock Peanuts in the Virginia-North Carolina Area. Marketing Research Report 595.

Perdue, E. J., and McVey, D. H. June 1963. Co-op Vegetable Oil Men Discuss Aims and Obstacles. Article in News for Farmer Cooperatives.

COMMODITY SITUATION AND OUTLOOK ANALYSIS
Economic and Statistical Analysis Div., ERS

Problem. Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for sound production and marketing decisions. It has long been a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook information; the development of longer range projections of the economic prospects for the principal agricultural commodities; and analyses of the economic implications of existing and proposed programs affecting the principal farm commodities.

USDA PROGRAM

Fats and Oils. This work involves 2.0 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fats, oils, and oilseeds. These appraisals, developments of interest to the industry, and results of special studies are published five times a year in the Fats and Oils Situation, quarterly in the Demand and Price Situation and the National Food Situation, and monthly in the Farm Index. A comprehensive analysis of the fats and oils situation is presented at the Annual Outlook Conference and more limited appraisals given at meetings with industry groups. Special analyses are prepared from time to time on the probable effect of proposed programs on the price, supply, and consumption of fats and oils and their products. Basic statistical series are maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Oilseeds, Fats and Oils, and Their Products, is being revised for publication in 1964.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Supplies of food fats and oils during the 1962-63 marketing year were a record 16.4 billion pounds (in terms of oil), about 4 percent greater than the year before. Total disappearance rose about 5 percent to a new high, with record exports accounting for most of the increase. The Food for Peace Program again was an important factor in exports. Carryover stocks of food fats on October 1, 1963 were down slightly from a year earlier, due to a big reduction in soybeans. Stocks of edible vegetable oils, lard and butter were up. Prices received by farmers for 1962 crops of soybeans and cottonseed remained somewhat above CCC support rates

whereas flaxseed and peanut prices rested on support. Wholesale prices of all fats and oils during 1962-63 averaged slightly below year earlier levels but oilseed meal prices were somewhat higher.

Most significant development during the year was the strong demand for soybean meal, which far outstripped the demand for soybean oil. The large crush of soybeans resulted in record carryover stocks of about 1.0 billion pounds of soybean oil (crude and refined) on October 1, 1963. Thus, the 1963-64 marketing year started with very large stocks of soybean oil and low stocks of soybean meal. As a result, soybean oil prices were low in relation to prices of both soybeans and soybean meal.

In addition to the regular analytic work and outlook analyses, considerable effort was devoted to improving statistical techniques used in forecasting and the development of new statistical series. Work got underway on a comprehensive statistical bulletin for fats, oils, oilseeds and their products. This handbook is badly needed by commodity analysts, as it has been 10 years since the issuance of the last comprehensive compilation of data. Greater attention is being given to some of the minor oilseed crops and our expanding foreign markets. Long-run projections (5 years) were developed for the major oilseeds, fats and oils as part of an overall set of ERS projections for the farm economy.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Corkern, Ray S. August 1963. The U.S. market for rapeseed and rapeseed oil. Fats and Oils Situation.

Gazelle, Stanley A. March 1963. Strategic oils stockpile review. Fats and Oils Situation.

Kromer, George W. December 1962. Record food fat exports in 1962-63 to account for one-third of United States' output. Agricultural Situation.

Kromer, George W. January 1963. Tung oil supplies scarcest since World War II. Fats and Oils Situation. Reprinted as ERS-108.

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Thomason, Francis G. May 1963. The changing export pattern for U.S. edible vegetable oils. Fats and Oils Situation.